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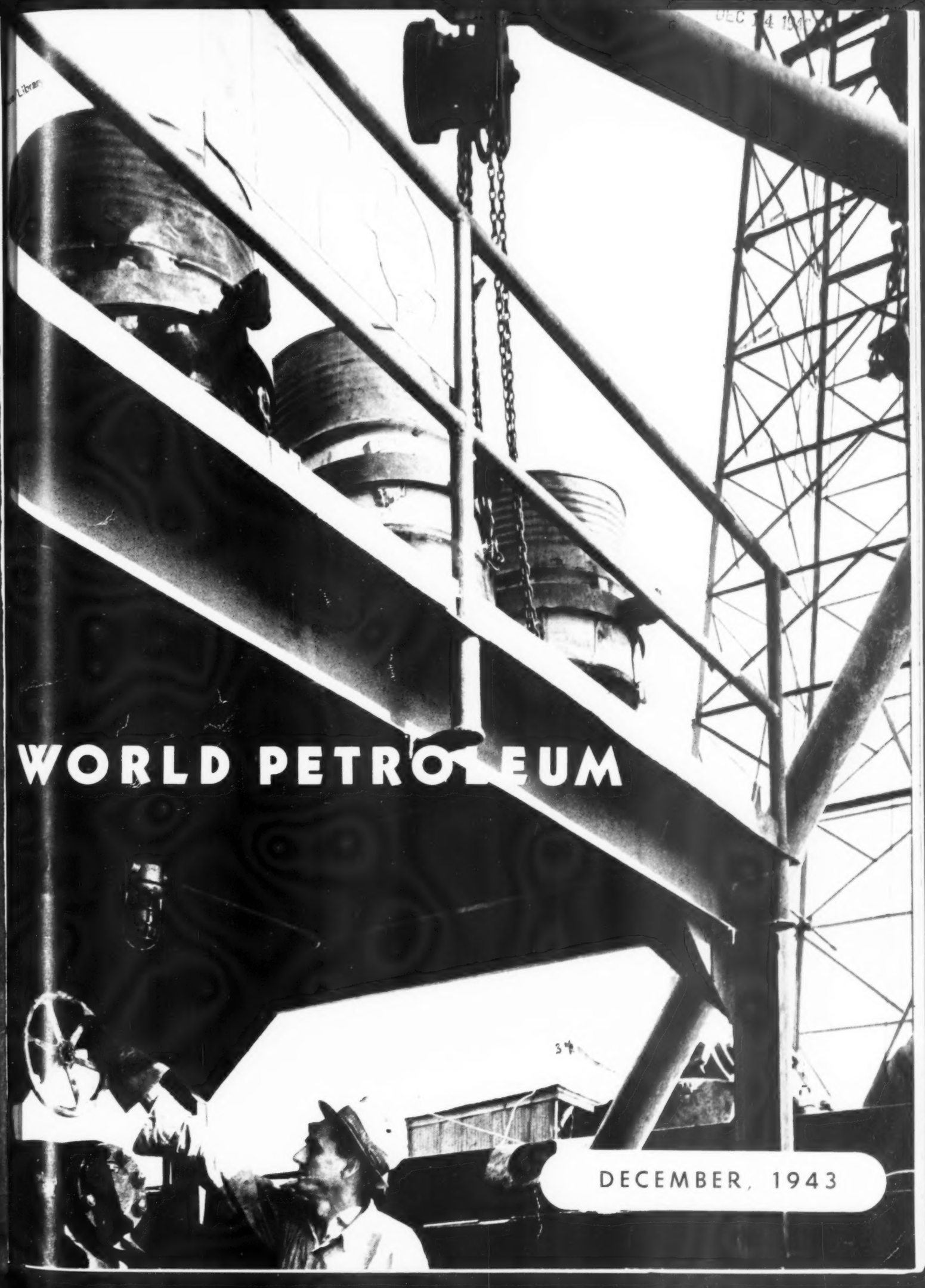

WORLD PETROLEUM

DECEMBER, 1943

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WORLD PETROLEUM

INCORPORATING PETROLEUM EQUIPMENT EXPORTER

THE MANAGEMENT PUBLICATION OF THE INTERNATIONAL PETROLEUM INDUSTRY

VOLUME 14 | DECEMBER, 1943 | NUMBER 13

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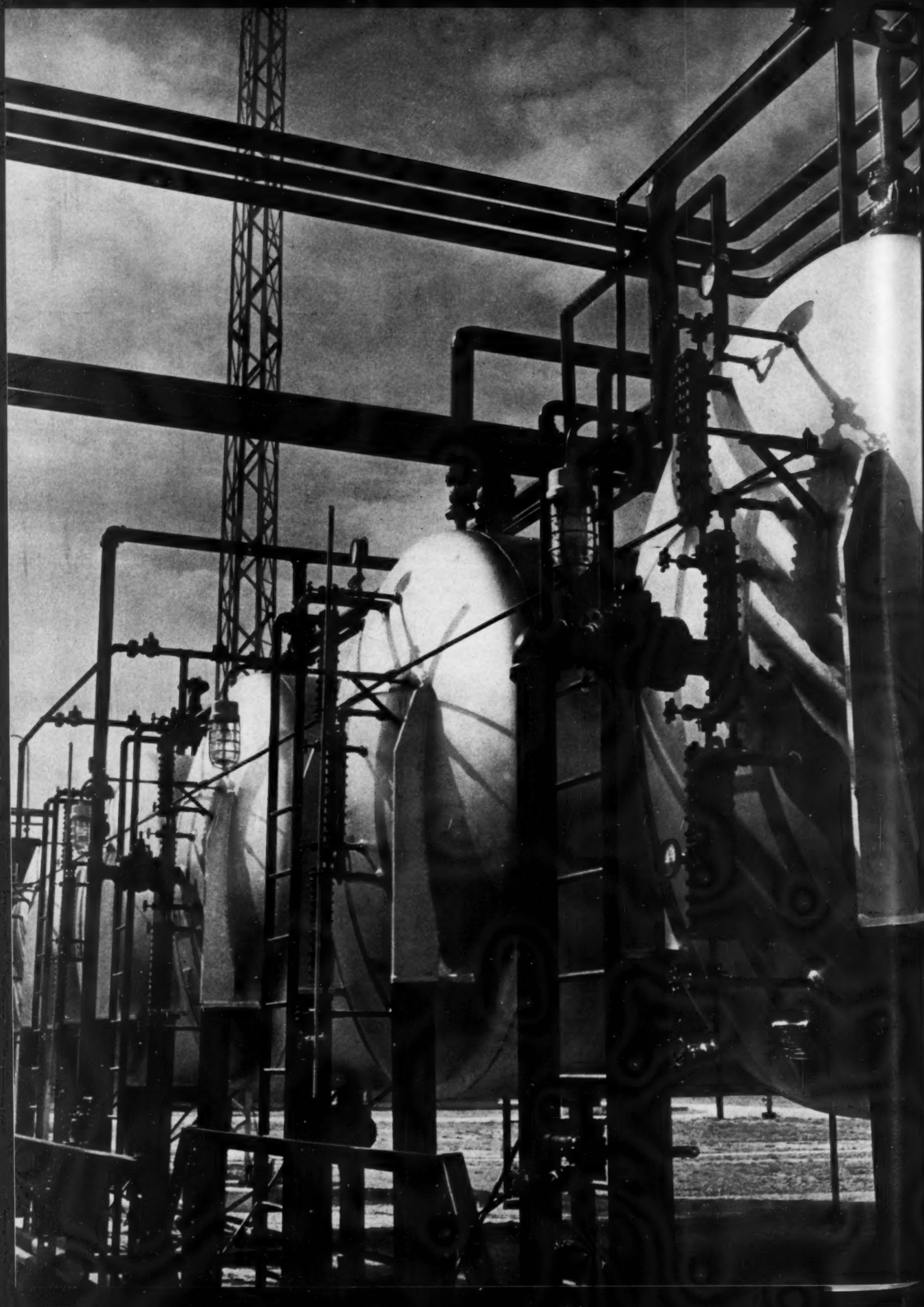
SUBSCRIPTIONS: Annual subscription is offered at the flat rate of $5.00 (U. S.) postpaid. Single copies are obtainable at 50 cents. • Address all correspondence regarding editorial, advertising and subscription matters to 2 W. 45th St., New York. (Tel. MUrray Hill 2-7333). Published monthly by the Estate of Russell Palmer

BRANCH OFFICES: London: Brettenham House, Lancaster Place, W. C. 2 • Pacific Coast Advertising Manager: Don F. Harner, 1595 Pacific Ave., Long Beach 6, Cal. (Tel. 613-238) • Mid-Continent Advertising Manager: O. F. Cozier, 415 McBirney Bldg., Tulsa 3, Okla. (Tel. 4-5555) • Mid-West Advertising Manager: Willard R. Cotton, 307 No. Michigan Ave., Chicago 1, Ill. (Tel. Franklin 2508) • Michigan Manager: R. F. Pickrell, 314 Stephenson Bldg., Detroit 2 (Tel. Trinity 1-0790) • Cleveland Manager: Frank J. Enright, Union Commerce Bldg., Cleveland 14, Ohio.



EDITORIAL

PRICE RISE DENIAL ENDANGERS NATIONAL WELLBEING

DISCUSSION of the necessity for an increase in the price of oil has gone on for more than two years past. Every fact pertaining to the subject has been fully developed. The declining rate of discovery, the need of expanding reserves to support a higher rate of withdrawal, the importance of maintaining in operation wells of small production and of adopting measures to recover the maximum possible amount of oil from existing reservoirs, all have been presented in full detail supported by a wealth of statistical evidence. Eleven different Congressional committees have investigated various phases of the subject and have recommended a price advance as the effective means of meeting the situation. The Petroleum Administrator for War repeatedly has urged an upward revision that would compensate in part at least for advancing costs and stimulate exploration. State authorities, oil industry associations and many other groups have added the weight of their opinion in support of more adequate remuneration for a product on which the national economy and national security are vitally dependent.

In this broad consensus there is complete unanimity on one point, namely that a stronger price incentive is the effective means, the only known effective means, of preventing the dwindling of reserves and bringing to light the additional petroleum deposits so greatly needed. Such agreement is no more than a recognition of the time honored law of supply and demand which in the past never has failed to produce results and for which no effective substitute has yet been found. The only alternative that has been proposed is a vague and undefined suggestion that payments from the federal treasury be employed to support wildcat drilling and that subsidies be provided to keep in production wells that are incapable of profitable operation at prevailing prices. The inadequacy of any such system, the difficulty of implementing it and the possibilities of abuse inseparable from it have been fully exposed. In fact, the only support that it has received has come from within the Office of Price Administration. Yet this is the proposal which Economic Stabilizer Vinson adopts in denying the recommended increase and he couples with it an instruction to the Petroleum Administrator for War to work out measures that will enable this subsidization scheme to be put into effect.

At the same time certain restrictions are imposed upon any plan that may be put forward to attain this objective. These are stated by Judge Vinson as follows:

"To be avoided is any increase in the cost of living. This presupposes that the financial support for an increased exploratory and development program and for continuation of marginal production which cannot be absorbed by other segments of the industry must come from public funds.

"To be avoided is any complex scheme for subsidy payments subjecting agencies of government and the oil industry to impossible administrative burdens.

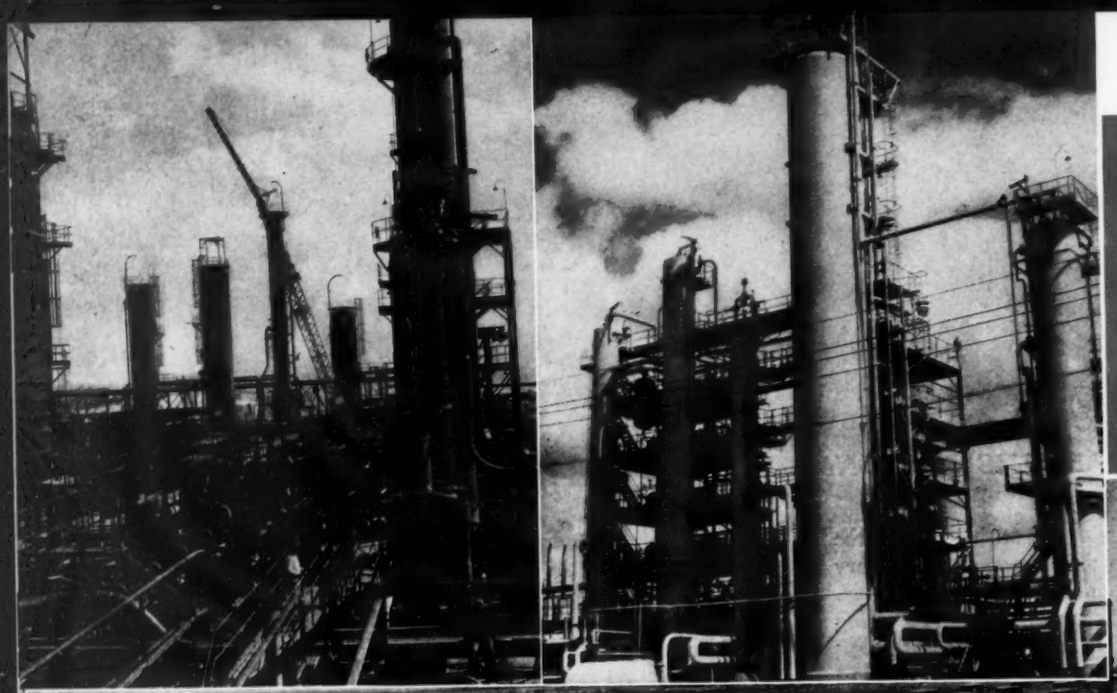
"To be avoided is any program that rewards without discrimination those who engage in exploratory activity and the development of new fields and those who do neither."

Petroleum Administrator Ickes, frankly admitting his inability to offer a workable system complying with these requirements, has asked the members of his organization to undertake the task and has suggested that members of the oil industry cooperate by advancing any proposals that occur to them. It is hardly to be anticipated, however, that any fruitful results will emanate from these requests for the simple reason that no workable plan for government support of oil exploration has yet been presented that will accomplish the purpose of providing adequate national reserves without requiring the setting-up of a burdensome and regulation-bound administrative machine. It is doubtful that any such system can be devised.

From the course that has been followed by the price authorities in dealing with this matter from the beginning it is fair to assume that they have no expectation that a feasible subsidy plan can be set up in time to be of assistance in the conduct of the war. In the words of the Committee on Cost and Price Adjustment of the Petroleum Industry War Council, "Obstruction, hindrance, delay and compromise are the techniques being applied to slow cost advances." These certainly are the methods that have avoided urgently needed action on oil prices for over two years, except that the only compromise offered has been an impracticable one.

While the decision of Judge Vinson adheres literally to the Presidential order against wage and price increases it violates the spirit of that directive which explicity instructs the Director of Economic Stabilization "to take such action and to issue such directives as he deems necessary to maintain and increase production and to aid in the effective prosecution of the war." The words "he deems" may provide a technical out for the Stabilizer but it is impossible to justify the setting-up of one man's views in a matter of this importance against the mass of opinion and evidence supporting a reasonable price adjustment.

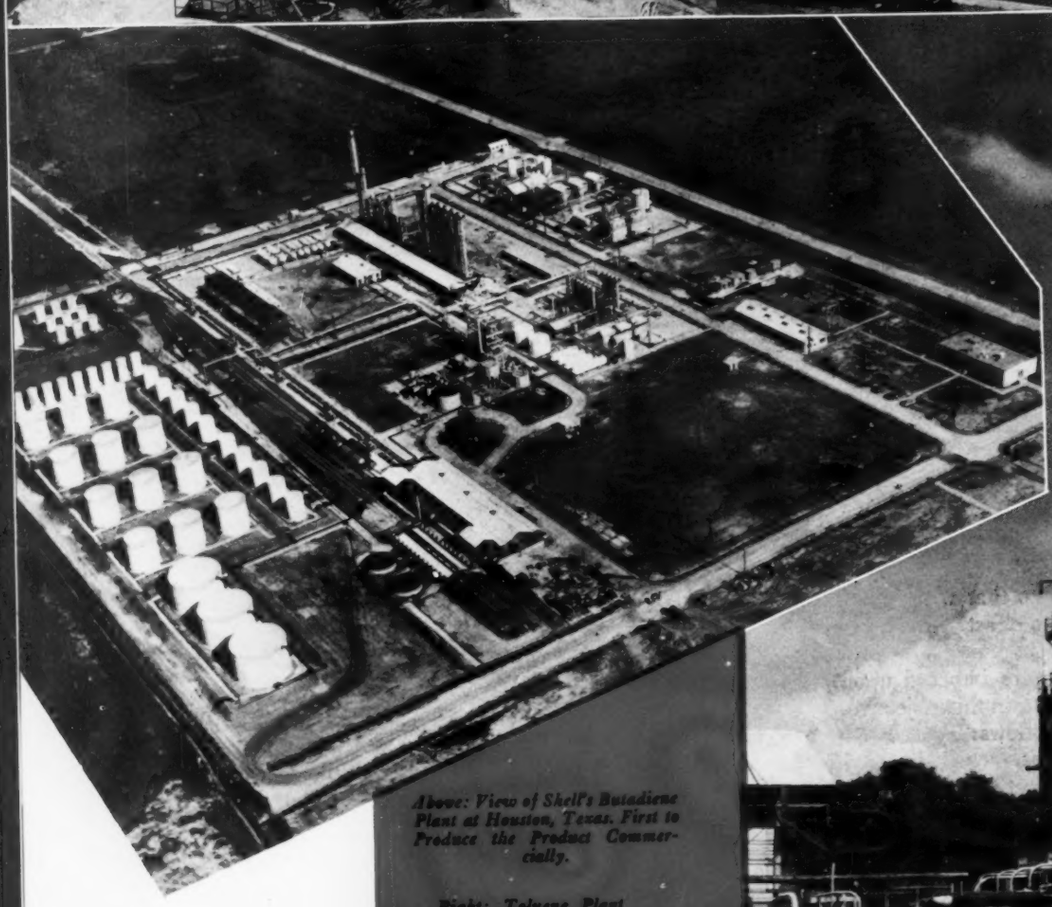
Five Horizontal Treating Settlers, Continental Oil Company's Lake Charles Refinery.



Extreme Left: Combination Catalytic Cracking Unit Built by The Lummus Co. for Union Oil Co.

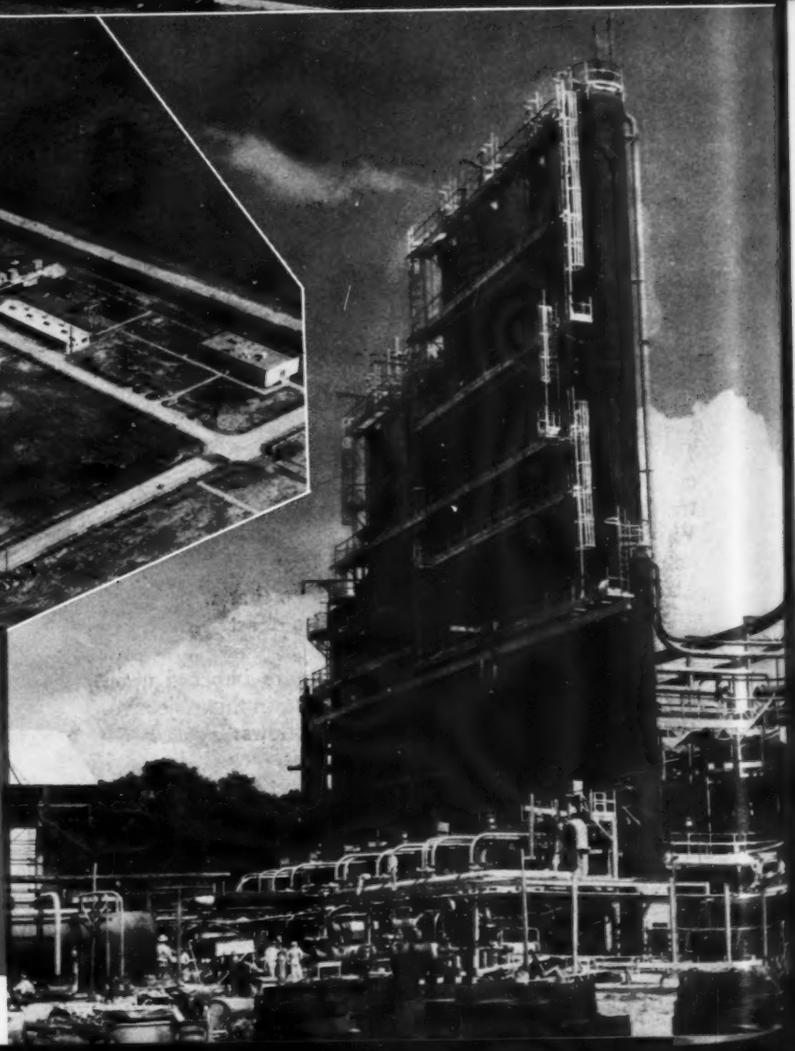
← *Left: Alkylation Plant at Beaumont Refinery of Magnolia Petroleum Co. Photo Courtesy The Lummus Co.*

Below: Continental's $12,000,000 High Octane Plant at Ponca City Built by The Lummus Co.



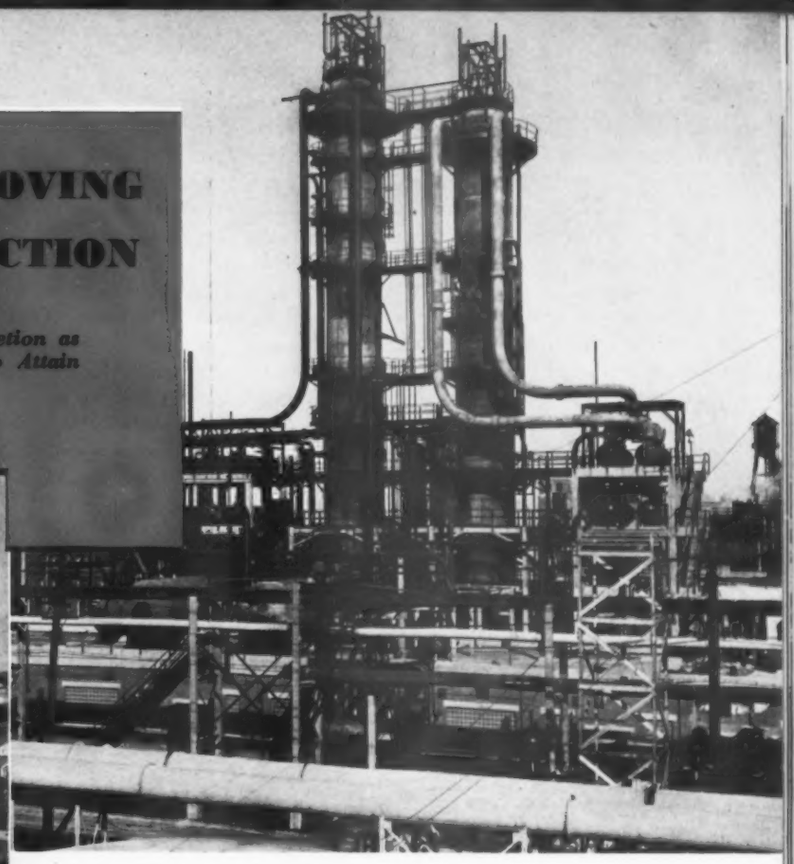
Above: View of Shell's Butadiene Plant at Houston, Texas. First to Produce the Product Commercially.

Right: Toluene Plant of Magnolia Petroleum Co. at Beaumont, Texas. →



PETROLEUM WAR MACHINE MOVING INTO FULL PRODUCTION

Construction Program of Past Two Years Is Rounding to Completion as Giant Plants Come Into Operation Enabling Allied Offensives to Attain Greater Power.



Above: Crude Naphtha Fractionator of Standard Oil Company (Indiana) Preparing Materials for Aviation Gasoline.

As 1943 draws to a close the program for production of 100-octane aviation gasoline is moving into high gear with the majority of the great catalytic cracking plants projected in 1942 and earlier in operation or in the final stages of completion. As a result of this progress and of the greatly increased output of all classes of planes the air offensive of the United Nations enters a more intensive phase with a stepping up of activity in both the eastern and western spheres of combat. By March of the coming year, the production of 100-octane will have increased eightfold over the corresponding period of 1942 and will be much above the level set for it by military authorities in their earlier plans.

While the production of aviation fuel has kept steadily ahead of actual demand for war use, much of the burden of providing it has been carried during the past two years by the conversion of existing refining facilities to the production of blending stocks or special ingredients which by combination or by a process of further treatment resulted in a relatively large output of 100-octane gasoline. In January 1942, 22 refineries were producing 100-octane or some major component. By June 1943 this number had risen to 47. At the same time 72 refineries were turning out codimer which after hydrogenation provides a valuable blending stock helping to swell the available supply of high-octane gasoline. Some of these refineries also were developing facilities for the production of 100-octane gasoline.

In a statement issued at the beginning of November, the Office of Petroleum Administrator for War listed 32 100-octane construction projects completed at that time, 40 others that would be completed before the end of February and an additional 22 scheduled for completion during 1944. Upon completion of the 1942-1943 program, it was stated, 126 American refineries will be participating in the production of 100-octane gasoline. Of these, 72 will be manufacturing the complete product while the others will make components of this vital super fuel.

At the same time it was pointed out that more than 200 other projects had been carried out for changing or expanding existing facilities to increase 100-octane production and to supply the huge quantities of fuel slightly below the 100-octane rating that are required by the Army and Navy for the training of plane crews and for purposes of transport and communication. With tens of thousands of men constantly undergoing instruction for air service, a vast amount of flying is necessary and a large proportion of the high-octane gasoline earmarked for military use is consumed in this necessary task of training.

Among the roundly 200 construction jobs classed as minor projects, though they are minor only in point of size and are as essential as the larger plants to the successful operation of the program, there are broad variations in cost and capacity. Sixty percent of them involved expenditures of $50,000 or less while less than 15 percent run as high in cost as $1,000,000 although two complete refineries are included in the number. One reason for the relatively low cost of this phase of the program is that second-hand equipment was used to a large extent in outfitting many of these plants and the use of scarce and costly critical materials was kept to a minimum. One of the noteworthy technical developments growing out of experience with high octane production is the discovery that small changes in plants may lead to considerable increment in products.

In the case of the huge new plants comprising a combination of catalytic cracking systems with alkylation units and other accessory equipment and requiring an investment of $2,500,000 to $3,000,000 for each thousand barrels of daily output improvements in processes have taken place even while the plants were under construction. As a result the throughput of these plants and the production of 100-octane has been greater in nearly all cases than the designed capacity. This, in turn, has helped to keep the output of aviation fuel well above the demands of the military establishments even though these demands have been sharply and many times unexpectedly revised upward.

As a result of the well rounded program that has been worked out, a majority of all the refineries in the country, some three out of four of those in active operation, are contributing in one way

or another to the all-important task of supplying the aviation fuel with which the United Nations from week to week are making more complete and decisive their command of the air. As the production program moves toward its peak, the output of 100-octane gasoline attains record dimensions and its consumption on battle fronts in every quarter of the globe exceeds anything heretofore dreamed of. The plants which make this possible are scattered in all parts of the country though the greatest concentration, naturally enough, is in the Texas-Gulf Coast area, close to the principal sources of crude supply. The investment required to put this huge war machine in operation is just under $1,000,000,000 of which the oil industry itself has supplied over 75 percent while the remainder has been advanced by the federal government through Defense Plants Corporation.

Because of the spectacular character of aerial warfare and the vastly increased importance it has acquired in the present war as compared with any preceding conflict the production of aviation fuel stands out as the most impressive achievement among the war activities of the petroleum industry. In reality, however, every phase of mechanized warfare is equally dependent upon petroleum products which are required in greater and even greater quantity as the scope of the conflict broadens. The rising tide of military demand was strikingly expressed by Petroleum Administrator Ickes in a statement issued on November 1. As of that date he disclosed that 1,200,000 barrels of petroleum products were going directly to the fighting forces every day. One third of all the gasoline produced in the United States, he said, is now required for military purposes. During 1944 these requirements will absorb in excess of 37 percent of the total gasoline produced in districts east of the Rocky Mountains and 52 percent of that in the Mountain and Pacific Coast regions.

"More than 30 percent of all our gasoline," said the Petroleum Administrator, "must now go straight to power the expanding bombing attacks, expanding fighter missions, expanding air transport operations all over the world and to fuel the thousands of tanks, jeeps, trucks, and motorized artillery on literally hundreds of separate fighting fronts and the need will increase until this war is won.

"More than 25 percent of all our light fuel must go straight to military power plants, machinery and fighting equipment.

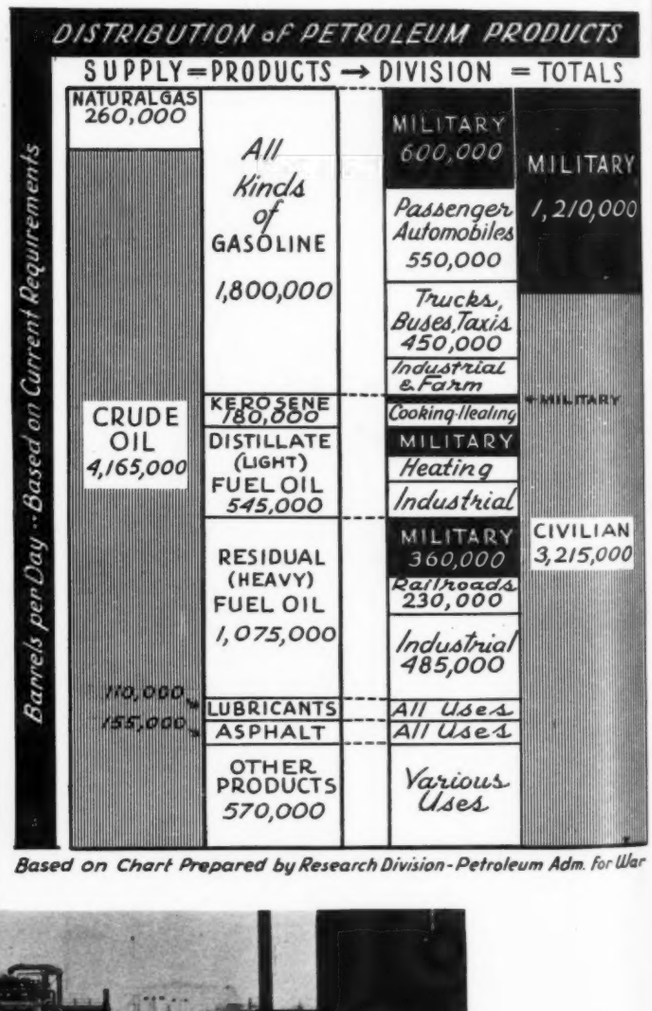
"Approximately 30 percent of the heavy fuel oil we produce goes straight into the bunkers of our expanding Navy and Merchant Marine, and to dozens of other direct military power uses.

"About one-quarter of the kerosene available today must likewise go straight to war, to warm the quarters of thousands of soldiers in Arctic outposts, for cooking and lighting purposes along the global service lines of the fighting quartermasters.

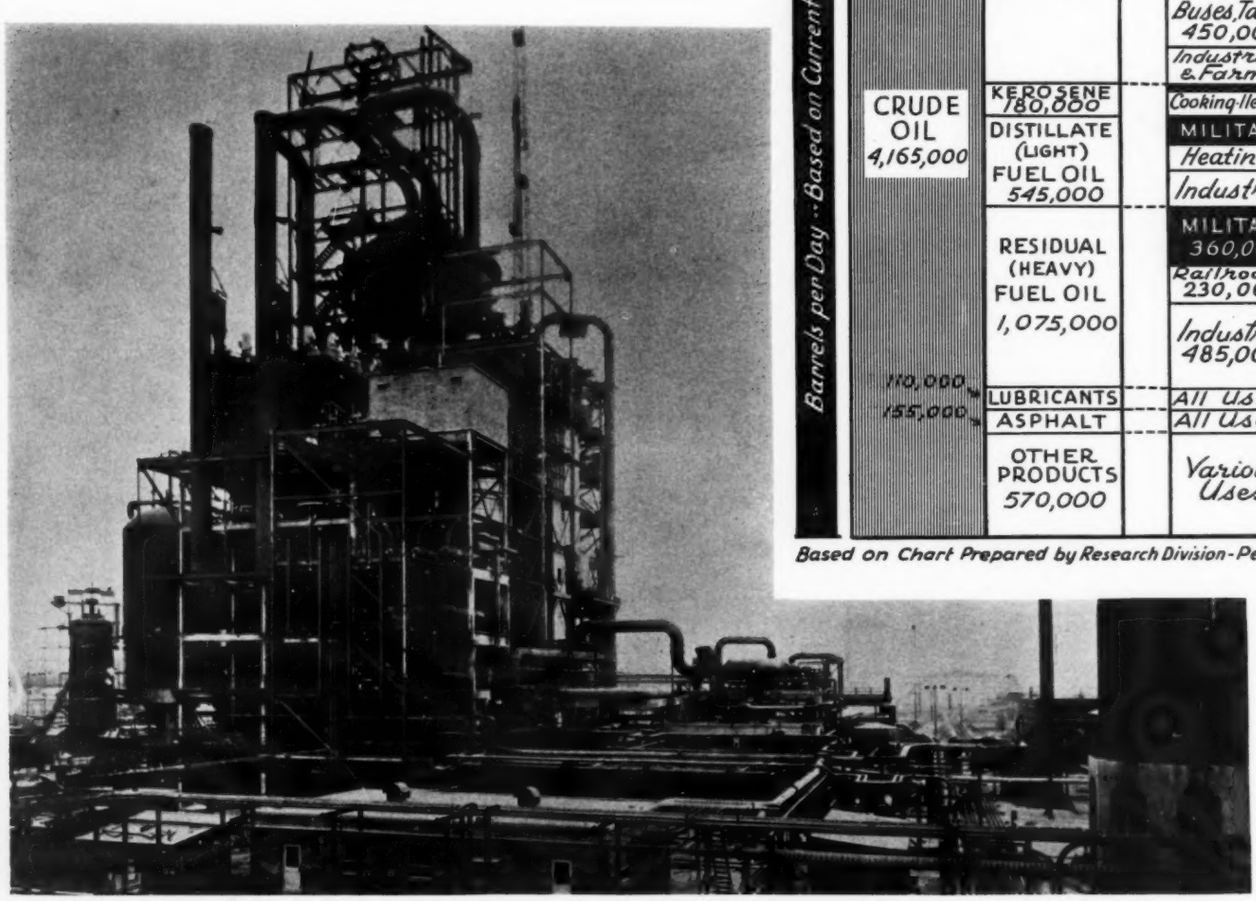
"These are the absolute 'must' petroleum needs, that can be met fully only through the continued conservation of petroleum products by every citizen.

"These facts show the terrific drain that war is imposing on our dwindling petroleum reserves. They give striking emphasis to the basic problem with which we are all confronted whether we be oil producers, refiners or transporters, or civilians wishing that we had more gasoline."

Although much less exacting in its demands upon the oil industry for raw materials the synthetic rubber program has required a tremendous amount of construction. In a report on progress to November 1, Rubber Director Dewey stated that progress in the building of plants to produce synthetic rubber and their principal raw materials, butadiene and styrene, was eminently satisfactory and that the principal concern for the next few months related to the provision of processing fa-



Based on Chart Prepared by Research Division - Petroleum Adm. for War



First Fluid Catalytic Cracking Plant on West Coast Supplying Aviation Base Stock and Butylene. Shell Oil Co. Dominguez, Calif.

cilities and the supply of materials essential to the making of rubber goods. He tabulated the status of plant construction as follows:

Product	Rated capacity	Rated capacity of construction comp. 10/31/43	Percent completed
	Long Tons	Long Tons	
Buna S	735,000	585,000	80
Butyl	75,000	21,000	28
Neoprene	40,000	40,000	100
	850,000	646,000	76
Butadiene:	Short Tons	Short Tons	
From Alcohol	230,000	200,000	87
From Petroleum	460,400	179,900	39
	690,400	379,900	55
Styrene	202,700	163,700	81

As will be observed, the program for production of butadiene from alcohol is much closer to completion than that covering butadiene from petroleum. As the Rubber Director explains this has been due to the fact that the alcohol plants received higher priorities, that most of the units were of a single design and that in a large number of cases butadiene production from petroleum was tied up with the completion of catalytic cracking plants designed primarily for high octane gasoline. On the whole, however, the rubber program, so far as the supply of raw materials is concerned, is held to be in a satisfactory condition despite the rapidly growing requirements of the military forces for heavy duty, combat and airplane tires.

In 1944, therefore, and until such time as peace may return to the world, oil will be a war industry much more completely than it has been at any time heretofore. More of its products will be going to military use. A larger proportion of its facilities will be occupied in meeting these military needs. These requirements must and will be satisfied regardless of other conditions. Since crude production already is close to the top level it can reach without serious impairment of existing fields it follows that supplies for essential civilian use will have to be curtailed even more drastically than in the past except to the extent that the shortage can be reduced by importations from other parts of the Western Hemisphere. If 35 to 40 percent of the total production from the wells of the United States must go to serve military needs it is obvious that the reduction of some 20 percent in domestic consumption that has been brought about with some difficulty and much inconvenience no longer will suffice unless other sources of supply can be tapped. But if civilian consumers have to sacrifice a still greater part of their accustomed supply of petroleum products they will have the satisfaction of knowing that the portion they are giving up is going to feed the greatest and most devastating petroleum war machine ever created and one that will contribute as much, if not more, than any other single factor to shortening the war, saving lives that otherwise would be sacrificed and assuring the complete and overwhelming victory that alone can provide the certainty of prolonged peace.

100 OCTANE PLANTS COMPLETED

The Atlantic Refining Company	Philadelphia, Pennsylvania
Cities Service Oil Company	E. Chicago, Indiana
Continental Oil Company	Lake Charles, Louisiana
Continental Oil Company	Wichita Falls, Kansas
Gulf Oil Corporation (2)	Port Arthur, Texas
Humble Oil & Refining Company	Baytown, Texas
Imperial Oil Limited	Calgary, Alta., Canada
Magnolia Petroleum Company	Beaumont, Texas
Pan American Refining Corporation	Texas City, Texas
Phillips Petroleum Company	Borger, Texas
Phillips Petroleum Company	Kansas City, Kansas
Richfield Oil Company	Watson, California
Shell Oil Company, Inc. (3)	Wilmington, California
Shell Oil Company, Inc.	Wood River, Illinois
Sinclair Refining Company	Houston, Texas
Socony-Vacuum Oil Company, Inc.	E. Chicago, Indiana
Socony-Vacuum Oil Company, Inc.	Augusta, Kansas
Standard Oil Company of California (2)	El Segundo, California
Standard Oil Company of California	Richmond, California
Standard Oil Company of Louisiana (2)	Baton Rouge, Louisiana
Standard Oil Company of New Jersey	Baltimore, Maryland
Standard Oil Company (Ohio)	Toledo, Ohio
Sun Oil Company	Marcus Hook, Pennsylvania
The Texas Company	Lockport, Illinois
The Texas Company	Port Arthur, Texas
Tide Water Associated Oil Company	Avon, California
Union Oil Company of California	Wilmington, California

100 OCTANE PLANTS NEARING COMPLETION

J. S. Abercrombie-Harrison Oil Company	Sweeny, Texas
Ashland Oil & Refining Company	Catlettsburg, Kentucky
Asiatic Petroleum Corporation	Curacao, N.W.I.
Associated Refineries Inc.	Duncan, Oklahoma
The Atlantic Refining Company	Atreco, Texas
The Atlantic Refining Company	Philadelphia, Pennsylvania
Champlin Refining Company	Enid, Oklahoma
Cities Service Refining Corporation	Lake Charles, Louisiana
Continental Oil Company	Ponca City, Oklahoma
Crown Central Petroleum Corporation	Houston, Texas
Eastern States Petroleum Company, Inc.	Houston, Texas
The Frontier Refining Company	Cheyenne, Wyoming
General Petroleum Corp. of California	Torrance, California
Great Southern Corporation	Corpus Christi, Texas
Lago Oil and Transport Company	Aruba, N. W. I.
Mohawk Petroleum Corporation	Bakersfield, California
National Refining Company	Coffeyville, Kansas
Pan American Refining Corporation	Texas City, Texas
Pennzoil Company	Oil City, Pennsylvania
Phillips Petroleum Company	Kansas City, Kansas
Premier Oil Refining Co. of Texas	Cotton Valley, Louisiana
Pure Oil Company (2)	Smith's Bluff, Texas
Republic Oil Refining Company	Texas City, Texas
Root Petroleum Company	El Dorado, Arkansas
Shell Oil Company, Inc.	Montreal, Canada
Shell Oil Company, Inc.	Wood River, Illinois
Sinclair Refining Company	Corpus Christi, Texas
Sinclair Refining Company	Sinclair, Wyoming
Socony-Vacuum Oil Company, Inc.	E. St. Louis, Illinois
Southport Petroleum Co. of Delaware	Texas City, Texas
Standard Oil Company (Indiana) (2)	Whiting, Indiana
Standard Oil Company of Louisiana	Baton Rouge, Louisiana
Standard Oil Company of New Jersey	Baltimore, Maryland
Standard Oil Company (Ohio)	Cleveland, Ohio
The Texas Company	Port Arthur, Texas
Union Oil Company of California	Wilmington, California

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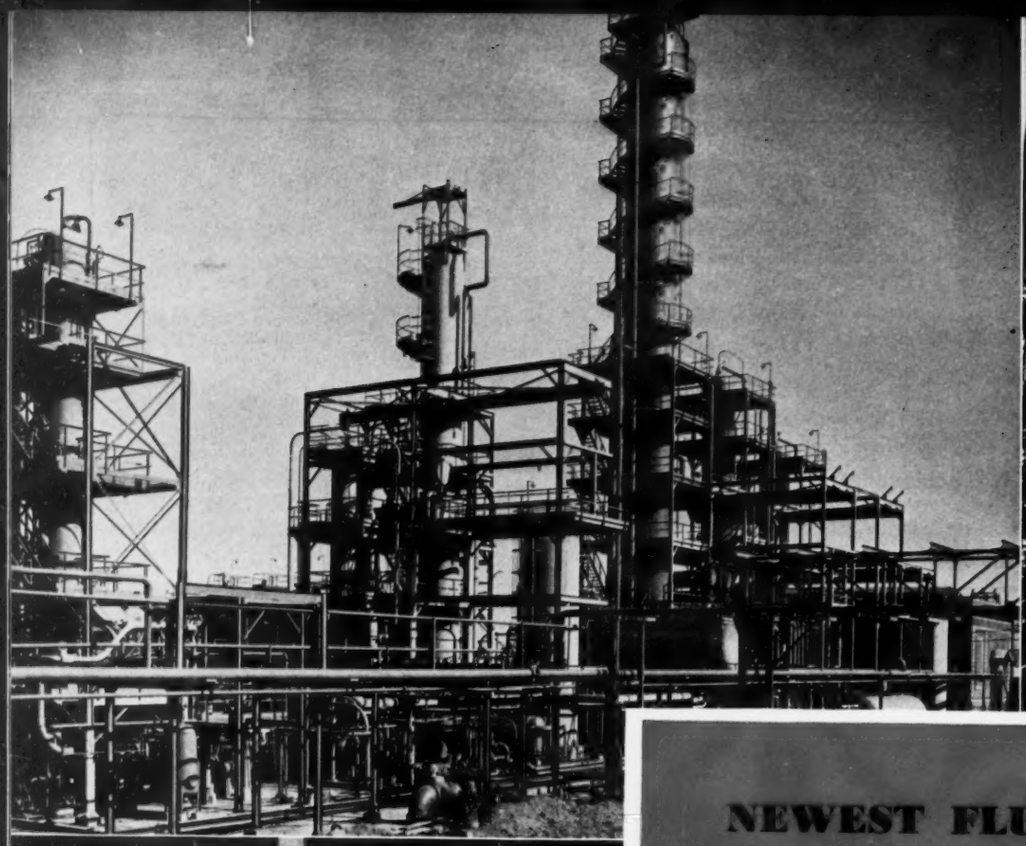
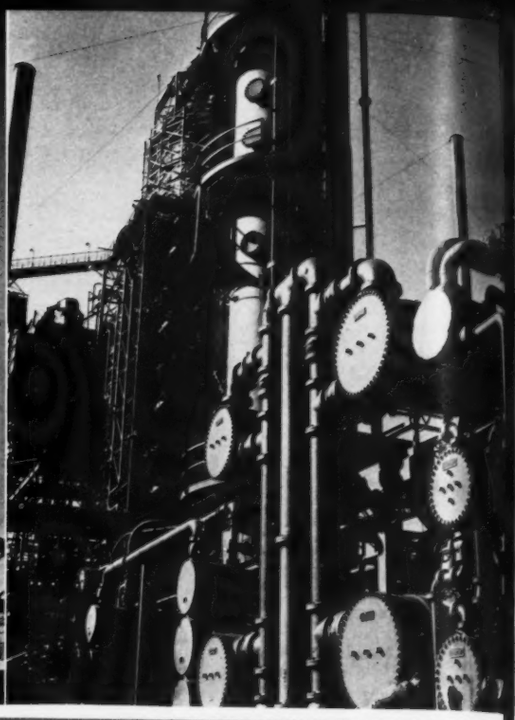
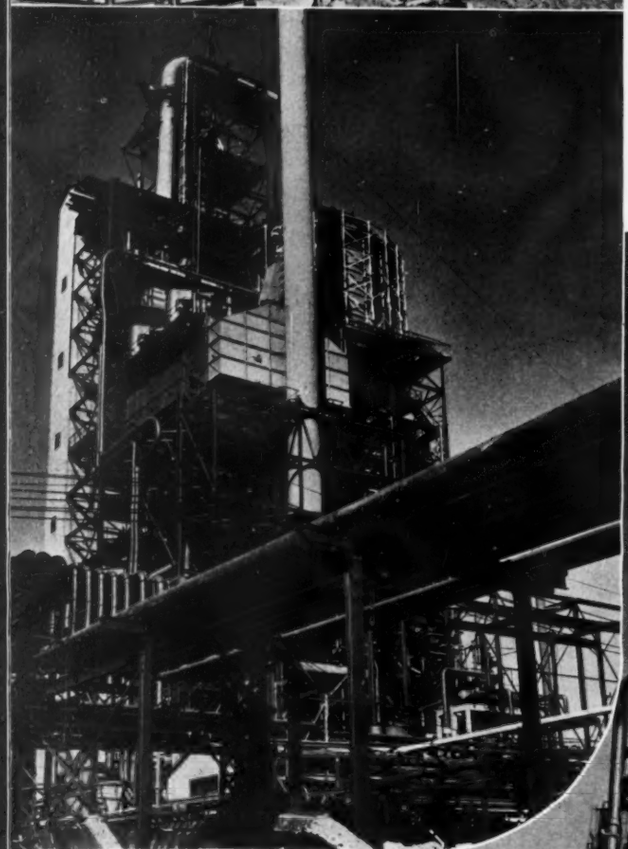
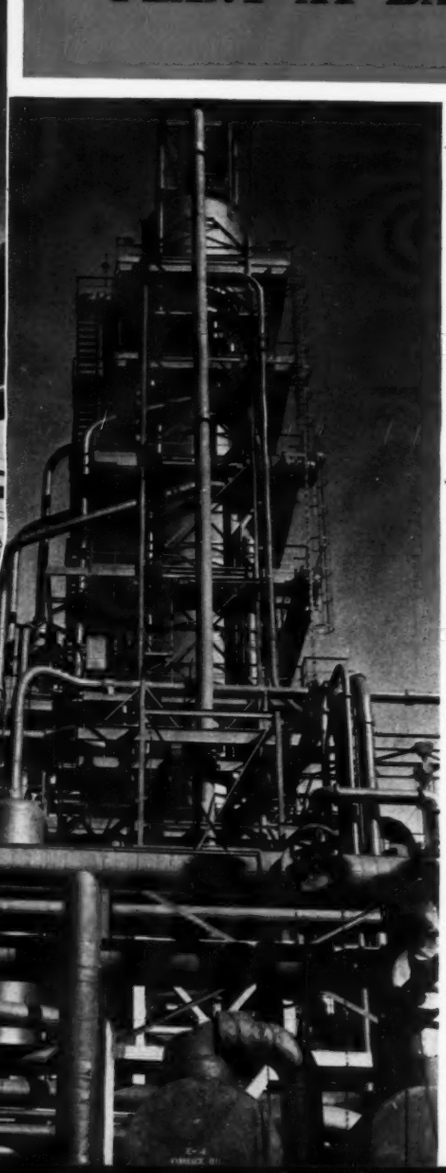




NEWEST FLUID CATALYTIC CRACKING UNIT IS STANDARD'S PLANT AT BALTIMORE





Top Left: Scrubber Unit and Alkylation Fractionation Towers.

Top Right: Light Ends Absorber in Foreground, Catalytic Unit in Background.

Above: Catalytic Unit With Overhead Pipelines in Foreground.

Right: Atmospheric Crude Pipe Still.

BY THE time these words are put in type, the Standard Oil Company of New Jersey will have put in operation a new Fluid Catalyst Cracking Plant located in the Baltimore region, and in no great time numerous other Fluid "cat" plants will be starting up to swell the already great stream of aviation gasoline that is now flowing to all the battle fronts where Allied forces are confronting the Hitlerites.

Altogether, there are 33 of these Fluid Catalyst plants built or building for the production of aviation gasoline, or for the raw materials of synthetic rubber, or both. Catalytic cracking plants for these same purposes are also built or building to operate by other systems such as the Thermofor, the Cycloversion and the Houdry catalytic processes. However, the Fluid Catalyst process has taken the lead quantitatively in this field; when the building program, now under way, is completed something more than half of the charging capacity for catalytic cracking of petroleum will be represented by this type of plant. The basic soundness of the fluid catalyst technique has been demonstrated by large scale experience, particularly in the first plants of this type that came into operation some time ago: the Baton Rouge and the Bayway refineries of the Standard Oil Company of N. J., and the Baytown plant of the Humble Oil and Refining Company. These plants have had continuous runs of five months or more and have shown maintenance requirements below that experienced with thermal cracking. Losses

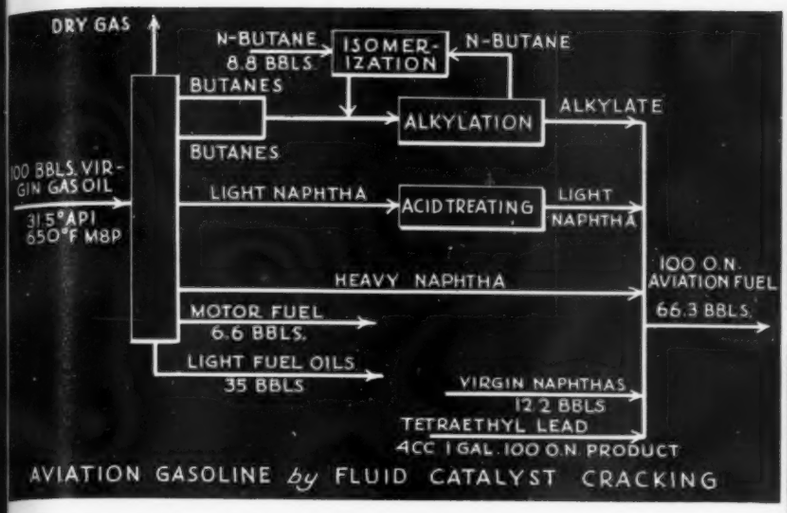
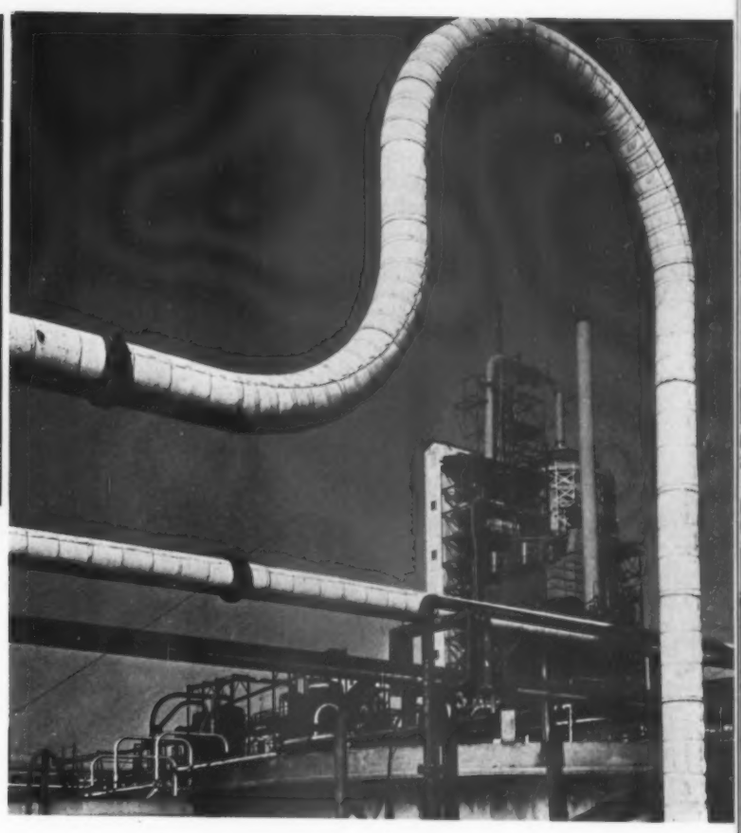


Fig. 1



Catalytic Unit Looking NE from Crude Distillation Battery.

of catalyst are of the order of 0.15 percent, and erosion of equipment by the circulation of catalyst has been reduced to negligible proportions. There is thus no longer any doubt of the complete workability of the Fluid Catalyst process in the mechanical sense.

There also seems little room for doubt about the technical success of the operation. Fluid catalyst plants are turning out war materials in quantities substantially beyond their original rated capacities. Not only are the yields excellent, but in the production of 100-octane aviation gasoline, on which mastery of the air in aerial warfare so largely depends, a fuel is being obtained that goes substantially beyond the full power possibilities required by Army specifications.

The importance of the foregoing statement is apt to be overlooked. The fact that aviation gasoline now being turned out by catalyst cracking plants has an excess of quality means that the excess of octanes produced by these plants may be used to bring fuels of lower grade up to the standard. Thus, on the whole, the result is a larger supply of this critical military product than would be obtained from the same raw materials treated by an inferior process.

As summarized by Murphree and Associates in a paper presented before the November meeting of the American Petroleum Institute, results from the Fluid Catalyst plants now in operation show that with high temperature single-pass catalytic cracking operations, yields amounting to 66 per cent of specification 100-octane aviation fuel can be obtained from combined fluid cracking, alkylation, and acid-treating operations. In operation, the Fluid Catalyst plants are flexible and easily adapted to particular situations. One application, as reported by Murphree and Associates, is outlined in an accompanying drawing (Fig. 1). This illustration is based on processing a typical heavy-paraffinic gas oil at high temperature; the butylenes and amylenes produced are alkylated with isobutane, and the light naphtha is severely acid-treated with sulfuric acid to improve AFD-1c anti-knock quality by removing the olefins contained therein.

The catalytic heavy-aromatic fraction, which is high in anti-knock quality as produced, is blended directly into the final gasoline. As already said above, the blend of alkylate and naphthas from the catalytic operation is substantially higher in octane number than is required by the specifications, so readily available virgin naphthas, which are of comparatively low quality, are blended in such quantity that the final blend will conform to the requirements—thereby increasing the volume of specification aviation product.

As may be gathered from the diagram, for every 100 bbl. of heavy paraffinic gas oil charged to the fluid catalyst unit, it is possible to produce 66.3 bbl. of 100-octane-number aviation fuel which meets present specifications. Of this quantity, 12.2 bbl. are virgin naphtha fractions which can be blended in by virtue of the high quality of the products of catalysis. It now appears that this yield can be substantially increased by hydrogenating, instead of acid treating, the light catalytic naphtha. Experience now at hand indicates that the yield of specification aviation fuel from such a scheme of operation may be 78.4 bbl. per 100 bbl. of paraffinic virgin gas oil charged to the cracking operation.

In general construction, fluid catalytic cracking plants do not differ a great deal from conventional low-pressure refinery equipment. Carbon steel has been used for the most part in the plants, and most of the equipment is of conventional type. Moreover, the plants are characterized by the absence of timing devices and mechanical equipment for circulating the large quantities of catalyst. No unusual equipment has been designed to combat erosion, because this has been controlled primarily by proper choice of velocities, streamlining, and use of protective wear plates. Maintenance of catalyst activity in the commercial plants has been satisfactory. Inasmuch as a continuous replacement of catalyst inventory occurs by the addition of fresh catalyst to replace losses, Fluid catalyst achieves what might be termed an equilibrium activity, and no replacement of the total inventory is made periodically as with conventional fixed-bed catalyst processes. The catalyst in most of the commercial Fluid units has reached this state, and its performance has been in accordance with expectations.

While research on fluid catalytic cracking has resulted in a most important contribution to the war effort, this same experience will be of great value in the manufacture of automobile gasoline after the war. Experimental fluid cracking of virgin stocks, with internal recycling of the catalytic gas oil, for example, has resulted (according to Murphree et al.) in yields as high as 80 percent of motor gasoline (100 percent utilization of C_4). These catalytically cracked gas oils, however, are rather refractory to further cracking because of the presence in them of certain undesirable constituents that produce larger amounts of carbon and dry gas. It has been found that these undesirable constituents can be eliminated by hydrogenation with little or no gasoline formation and small hydrogen consumption to produce a gas oil which, in most cases, is superior to virgin gas oil in cracking quality. On the basis of experimental yields obtained from cracking and hydrogenation opera-

tions, it has been calculated that single-stage catalytic cracking followed by light hydrogenation and re-cracking of the cracked gas oil, may give a yield of 92 percent of gasoline (10 lb. Reed vapor pressure) and 13 percent of excess butane, making a total yield of 105 percent of gasoline by volume (100 percent utilization of C_4) on the virgin feed, without appreciable formation of tar. The ASTM octane number of such gasoline is 82.

It is interesting to note the bearing of this technique on the matter of petroleum conservation. As our oil reserves become more limited it will become of increasing importance to obtain from the raw material a larger proportion of the product of greatest utility, which, of course, is motor fuel.

The general features of the Fluid Catalytic Cracking process are by now familiar to oilmen generally. In principle it is of the "moving catalyst" type, in which the solid catalyst particles are circulated countercurrently against a stream of the oil to be cracked in vapor form. The characteristic feature of the Fluid process is that the catalyst is in the form of a very fine powder, or dust, which when mixed with oil vapor or air can be moved through the apparatus as though it were a fluid.

As designed for the first Fluid Catalyst plants, the cracking equipment consisted principally of a cracking vessel (reactor), an external cyclone for separating the spent catalyst from the cracked oil vapors, a regenerator in which the carbon deposited on the catalyst during the cracking operation was burned off, and a hopper to receive the regenerated catalyst for return to the reactor. Subsidiary equipment included heat exchangers for recovering the heat developed in the regeneration operation. The whole process is thus continuous.

In the more recent designs represented by Standard Oil of New Jersey's new plant at Baltimore, the fluid plants now coming into operation are of modified design. These changes in design have been in the direction of simplification, which not only reduces the amount of construction materials and labor requirement but admits of a more perfect control of the course of the reaction.

The catalyst, after acquiring its load of carbon passes into the regenerator where the carbon is burned off. The cracked vapors pass from the reactor to the fractionator, and the flue gases from the regenerator pass into a flue gas cooler with incidental production of steam. The small amount of catalyst that escapes from the regenerator is recovered in a Cottrell electric precipitator.

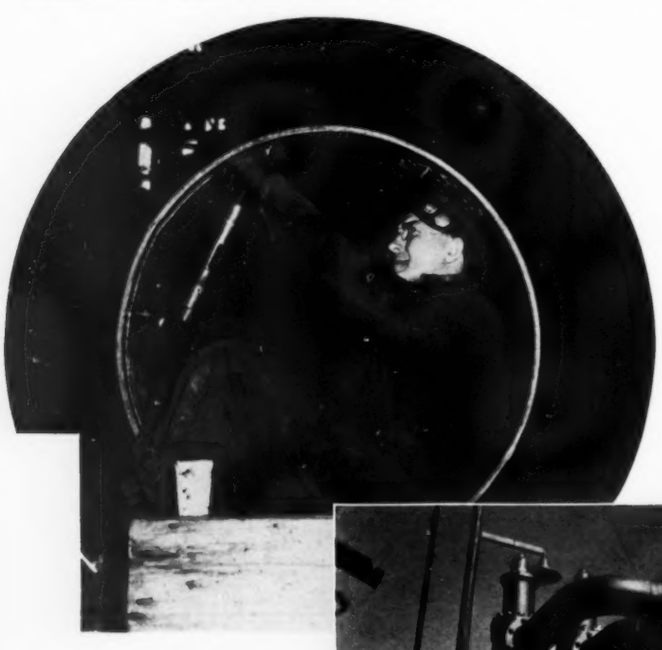
One feature of the recent design provides for injecting the uncooled hot regenerated catalyst directly into the stream of cold oil that is fed to the reactor. This provides enough heat for vaporizing the oil, and does away with the need for externally fired vaporizing equipment. War restrictions do not admit of discussion of the accessory equipment for controlling the process but it can be said that they impart to the Fluid-type a flexibility and sureness of control not heretofore attained.

The rate of catalyst flow is controlled by a special mechanism actuated by changes in the density of the catalyst-oil mixture. Reaction temperatures have ranged between 800° and 1000° F. Regeneration temperatures similarly can be varied widely, normally between 1000° and 1200° F. The depth of cracking can be governed independently of temperature by the ratio of catalyst to oil flow and by other process variables. Because of the method of handling the catalyst exceptionally large amounts can be circulated, permitting great variation in the intensity of treatment. According to Murphree et al., high cracking temperatures above the range normally possible by other processes are readily obtained through the high catalyst circulation in the fluid process. These features are of considerable importance inasmuch as the character of the products resulting from catalytic cracking is affected extensively by both temperature and conversion level.

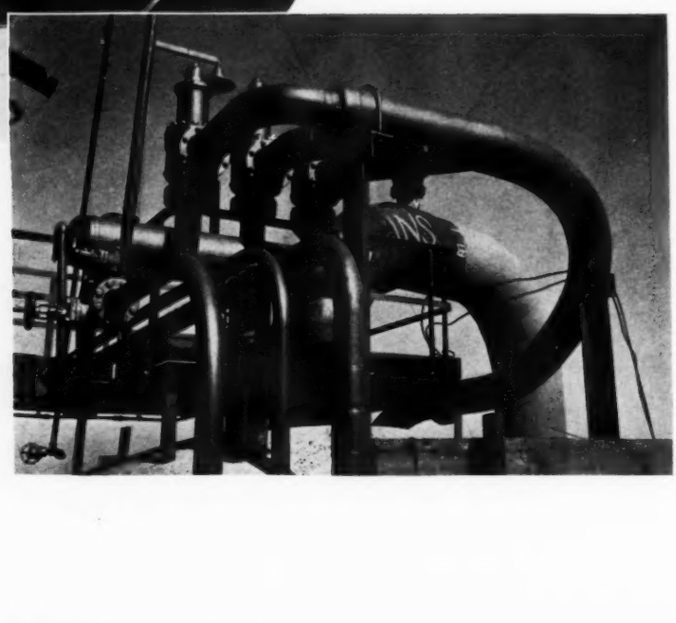
From a dimensional standpoint this newest Fluid Catalyst plant, built by the M. W. Kellogg Company, is impressive. The outlet for the combustion gases at the top of the regenerator is 250 feet above the ground.

The raw material for Fluid Catalytic cracking is a wide-cut gas oil, 500°-900°F., furnished by a new tube type crude oil still which is a part of the same refinery. This still has replaced an old style outfit of shell and pipe stills, and together with its fractionating equipment, embodies the most modern design. One interesting feature is a "crude flash drum" between the preheaters and the furnace coils. Here moisture or brine in the oil is flashed off; the resulting vapors, which entrain all or most of the salt and other incrustants and corroding substances are sent directly into the bubble tower, thus by-passing the furnace coils and largely protecting them from fouling. The fractionating tower of this still is 108 feet high and has 38 plates. A feature of this tower is a "pump around" system for handling reflux and making desired cuts. This "pump around" system is in marked contrast with the conventional "pumping back" of the reflux. One result of this design is a reduction in the size of the tower, which means a worthwhile saving of steel.

The accessory equipment of the Fluid "cat" plant mostly follows the line that has become more or less standard for this type of plant. The cracked oil vapors from the catalyst reactor are passed through a fractionating tower where the stream is separated into a butane and pentane cut for further treatment by alkylation, light naphtha, heavy naphtha, motor fuel and light fuel oils. Alkylation is by the sulfuric acid process.



Left: Kellogg Company Workman in Three Foot Vapor Line.



Right: Top of Fractionator, Catalytic Plant.

COMPLETION OF PLANT 15 ROUNDS OUT HUGE GROUP OF HOUDRY INSTALLATIONS AT MARCUS HOOK

ALTHOUGH a complete gasoline refinery within itself, Sun Oil Company's new Plant 15, dedicated October 27, ties together all of the aviation gasoline facilities of the company at Marcus Hook, increasing still further the efficiency of the entire operation. The new $13,000,000 plant affords now a continuous flow of product from one-pass catalytic cracking units to second-pass catalytic treating units which meets a flow of blending agents produced on the spot and finally issues as an unsurpassed fighting aviation fuel.

Plant 15 is located on a 123-acre tract of land. It consists of three units: a six case Houdry catalytic cracking or treating unit; the largest alkylation unit of its kind in existence; and a huge gas recovery and stabilization unit, together with complete auxiliary equipment necessary to operate these facilities. This auxiliary equipment includes a steam generating system, water supply systems, tankage, pump houses, water treating plant, electric power substation, sewage disposal plant, office, laboratories and the necessary shops and storehouse facilities. Much of the equipment is automatically operated and controlled, requiring a minimum of attendance. On the other hand the intricate chemical phenomena of the various processes requires strict laboratory supervision, and the staff of trained chemists and laboratory personnel outnumbers the operating personnel of the unit.

To this "gas plant" are brought all the refinery gases and unstabilized gasoline from other Houdry units at Marcus Hook, particularly the giant 12-case catalytic cracking 10-3 unit. These gases are rich with the stuff from which alkylate is made. They are compressed and fractionated so that they are suitable as feed to the alkylation unit.

This plant not only provides sufficient isopentane, another ingredient of aviation fuel, for all the requirements of Marcus Hook, but produces surplus iso-pentane for shipment to other companies deficient in this material. This unit also produces butane-butylene for charge to the alkylation unit. These gases are used as blending agents in various combinations to step up the octane value of catalytically cracked base stock to meet requirements for aviation fuel.

Propane-propylene is being separated for use as industrial fuel in such quantities that the available stocks of this material will thus be greatly amplified on the Atlantic Coast and transportation of this material from the Mid-continent area will be correspondingly decreased, thus releasing tank cars for other needed petroleum products.

The blending of these various ingredients takes place in the alkylation unit, the second hydrogen fluoride alkylation plant to be completed in this country. It is twice as large as the first one which went into production early this year. The plant operates with hydro-fluoric acid as a catalyst and combines isobutane and butylenes to form iso-octane, an essential ingredient of high quality aviation fuel.

Some idea of the size of the unit can be gained from the fact that the six contactors of the unit re-circulate a mixture of hydrocarbons and hydrogen fluoride at a rate of 300,000 gallons a minute. In order to remove the heat of reaction from this unit, water at the rate of 16,800 gallons a minute is circulated through tubes in the upper part of the reactors. Twin fractionating towers, 150 feet in height, form a dominant feature of the alkylation unit. The erection of these massive towers was regarded as a noteworthy engineering feat.*

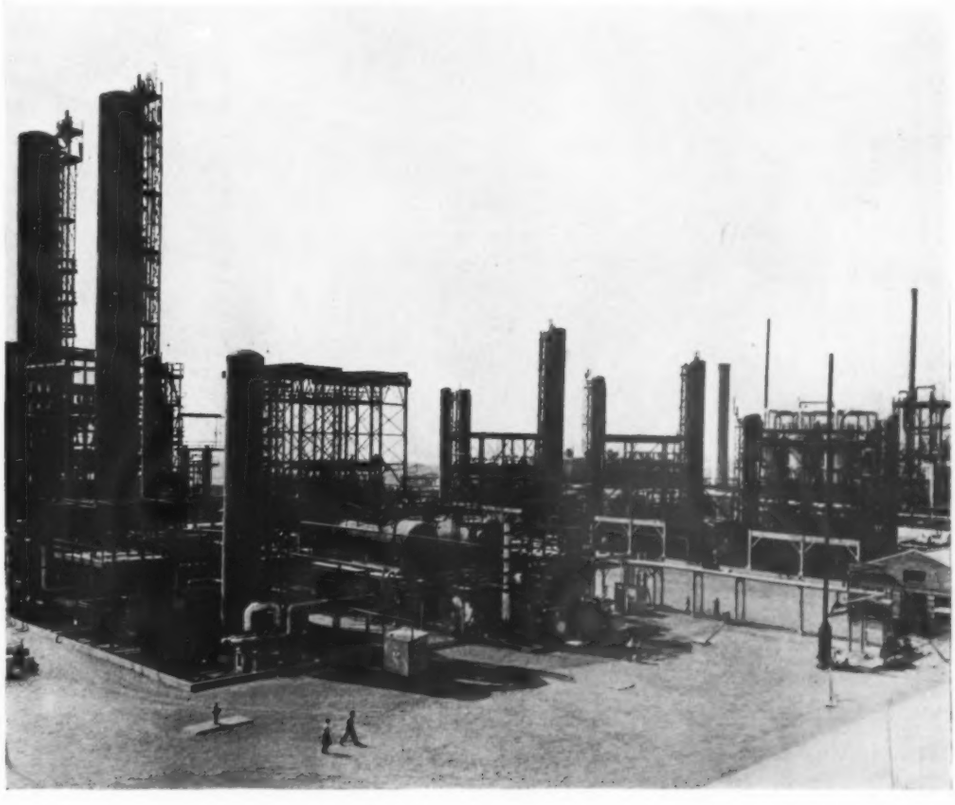
The third unit of Plant 15 is a new 6-case Houdry catalytic unit which is being used for the treating of aviation base gasoline produced in other Houdry units at Marcus Hook. The capacity of this new unit is about one-half that of the big Plant 10-3, and it has been laid out with the idea of ultimately increasing its size.

This is the twentieth Houdry catalytic cracking unit to go into operation as a part of the aviation gasoline program throughout the country. Sun Oil Company was the first to recognize the value of catalytic cracking and to carry it through to commercialization. Sun's first Houdry catalytic cracker at Marcus Hook went into operation in 1937. In 1940 the company completed the first Houdry catalytic cracking unit designed specifically for the production of aviation gasoline base. In the same year Sun completed and put into operation the largest Houdry catalytic cracking unit in existence, known as Plant 10-3. This unit has produced more catalytically cracked aviation base stock than any other unit in the world. All of Sun's catalytic crackers are devoted solely to producing aviation gasoline base stock. Additional facilities for the production of aviation gasoline at Marcus Hook are now being planned.

With the completion and operation of Plant 15, Sun's production of 100-octane aviation gasoline has been increased to a figure approximately twelve times the pre-Pearl Harbor production.

* See World Petroleum, Thirteenth Annual Refinery Number, 1943.

New 100-Octane Plant of Sun Oil Company.



PEACE CREEK FIELD – A STRATIGRAPHIC TRAP

By Joseph A. Kornfeld,

Consulting Geologist

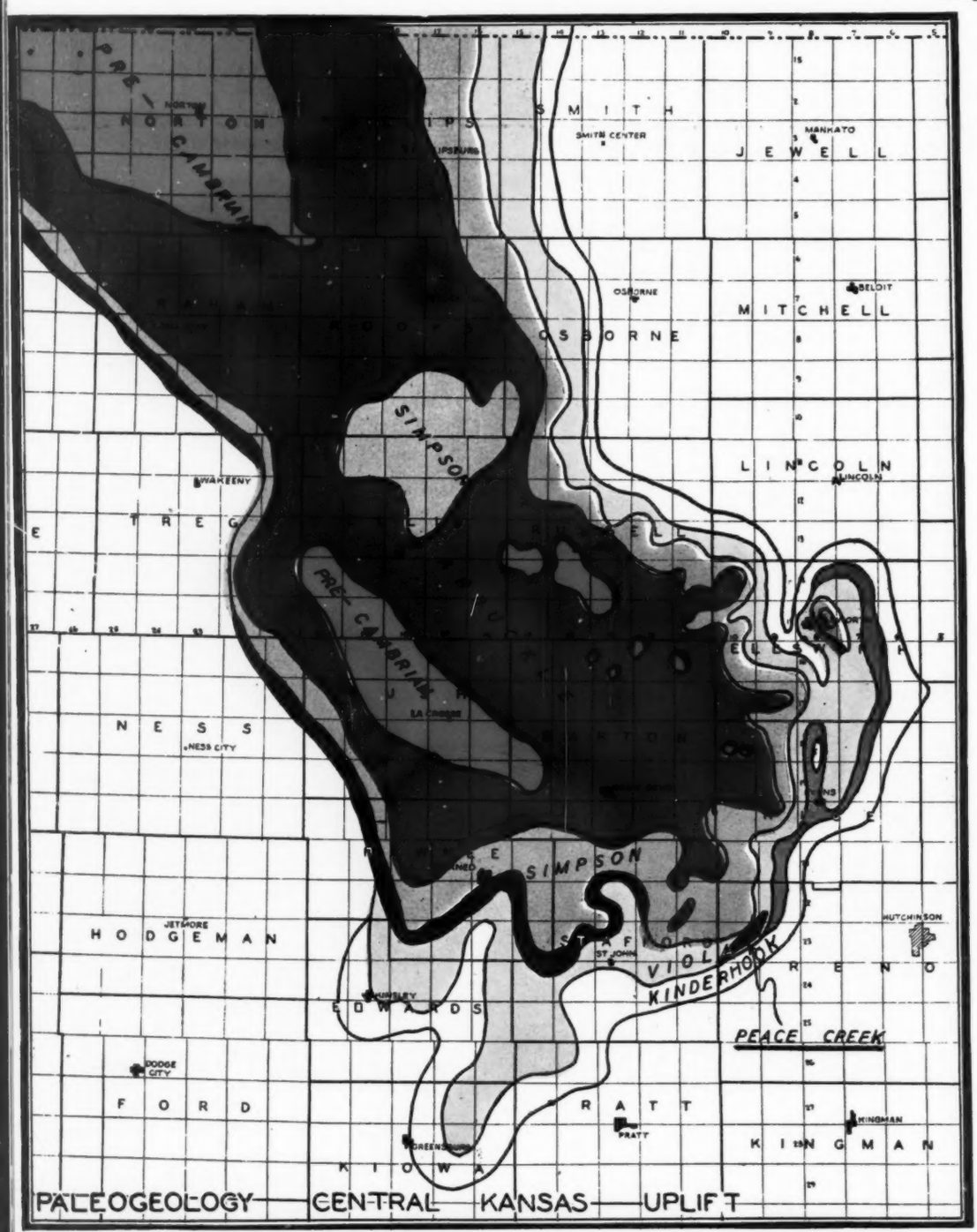
In discussions of the all-important subject of oil reserves the opinion has been frequently expressed that the structure-finding type of petroleum prospecting is definitely on the decline and that the future rate of discovery will depend more and more upon the location of stratigraphic traps. This probability and the increased emphasis in geologic thought upon exploration for stratigraphic type fields lends interest to a study of one of the more recent and prolific examples developed on the Central Kansas uplift.

A STRATIGRAPHIC TRAP has been defined by A. I. Levorsen in "Stratigraphic versus Structural Accumulation",* as "one in which a variation in the stratigraphy is the chief confining element in the reservoir which traps the oil." Oil fields in which the trap is of the stratigraphic type may be called "stratigraphic fields."

True stratigraphic fields, he explains, are characterized by being "bounded on one, or more than one side, by non-porosity, whatever the cause, unless the non-porosity is altogether coincident with local structural deformation". True structural fields, he outlines, are "those in which the trap may be said to be entirely structural—the local structure anomaly marking the edge of the pool on all sides. Between these two extremes, 100 per cent structural and 100 per cent stratigraphic —we find every variation and gradation".

** Bull. Amer. Assoc. Petrol. Geol. Vol. 20 #5, May 1936*

Since nearly every stratigraphic type oil field has been subjected during some geologic period to structural deformation in varying degree, the present aspect of the reservoir beds is the cumulative effect of both regional tilting as well as local deformation. This condition will affect largely the relationship of oil and gas accumulation to structure, although the predominating feature of the field may be the existence of a wedge-belt of porosity around the periphery of a buried regional uplift or near the buried margin of a regional basin. Consequently the exploration technique employed often seeks the regional thinning of beds towards the uplift for the purpose of finding wedge-belts of porosity and then localizing the accumulation by finding a local structural terrace. This method has been successfully used in the Gulf Coast region but might well be adapted to other provinces.

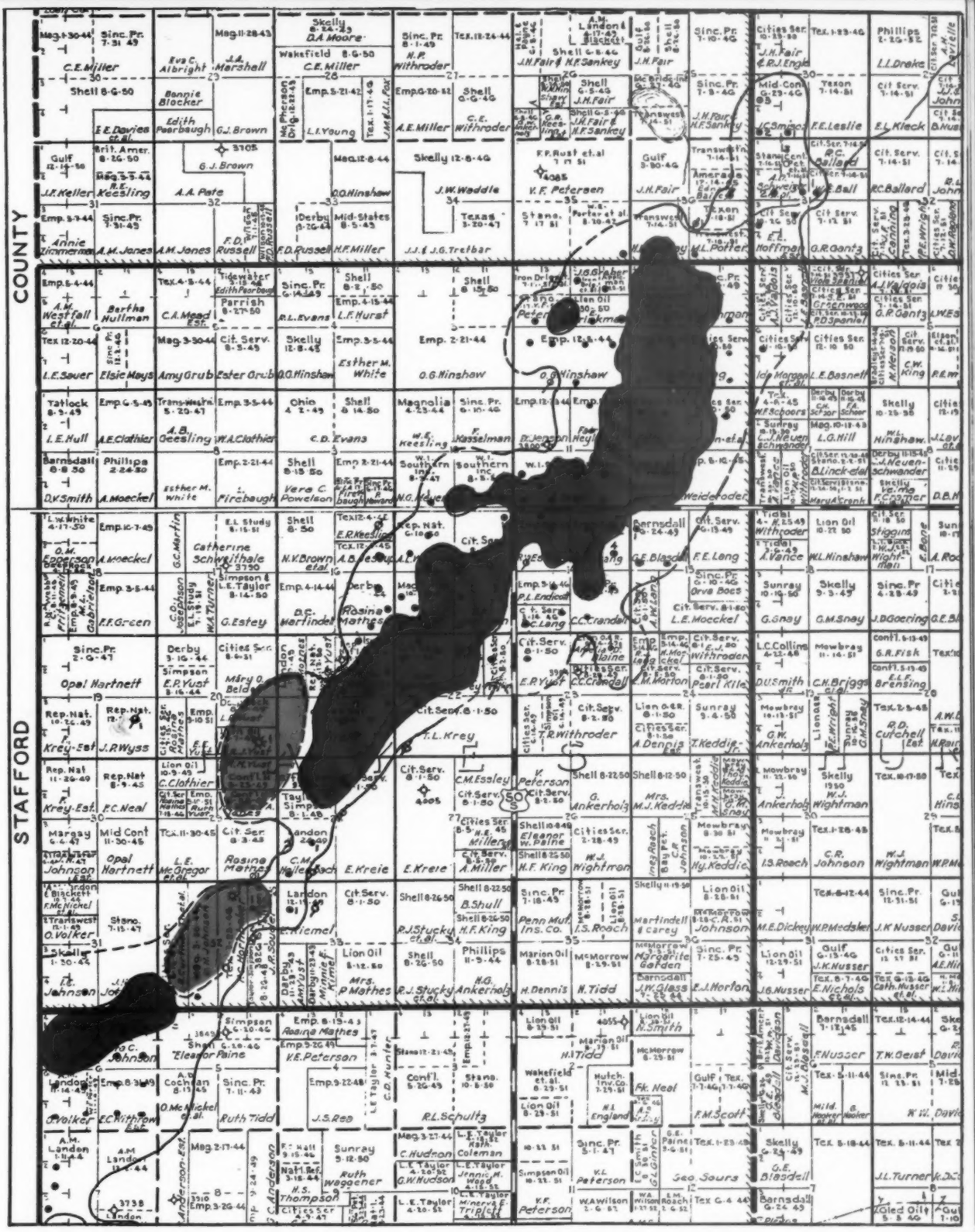


Paleogeology of Central Kansas Uplift, Showing Relationship of Peace Creek Field.

CENTRAL KANSAS UPLIFT

Since the accumulation of oil and gas at Peace Creek is related principally to the Central Kansas uplift, this important buried geologic prominence is fast assuming greater and greater proportions in mid-continent production history.

Peace Creek is situated near the southwestern extremity of a 70-mile segment of the south-



Production Map of Peace Creek; Gas Cap Sectors in Red; Richest Oil Areas in Blue. Base Map Courtesy Kansas Blue Print Co.

eastern flank of the Central Kansas uplift, where eight important oil fields and two gas fields have been developed to date from stratigraphic reservoirs. These are situated in Reno, Stafford, Rice and McPherson counties and are listed in a following table. They are productive from the lower Paleozoic rocks, principally important of which are the Viola lime, the Mississippian chert, the basal Pennsylvanian conglomerate and to a lesser extent the "Misener" sand and the Maquoketa dolomite.

Commercial importance of the stratigraphic fields found to date on this trend is exemplified by the fact that six of these fields combined—Peace Creek, Zenith, Stafford, Barnholdt, Welch, and Wherry—represent a proven acreage of nearly 16,000 acres with an ultimate recovery of nearly 130,000,000 barrels, of which 120,000,000 barrels are recoverable reserves.

Of these, Peace Creek is the largest from the standpoint of proven acreage, more than 6,880 acres having been defined to date in the Viola limestone reservoir. It also ranks second in this group from the standpoint of ultimate recovery.

From the standpoint of ease of development and discovery, the Central Kansas Uplift may prove to be the proving ground for development of improved geologic and exploration techniques for the discovery of lower Paleozoic stratigraphic traps in the mid-continent region.

DISCOVERY AND EXPLORATION

The first drilling exploration in the Peace Creek area was made by Pryor and Lockhart, Inc. of Wichita, at their No. 1 V. F. Petersen, prior to 1929. It was drilled 405 feet into the Arbuckle dolomite without finding commercial production. No. "Viola" lime was logged, the drill passing from Basal Pennsylvanian conglomerate into Simpson topped at 3,625 ft. (1,878 ft. subsea); the Arbuckle dolomite was encountered at 3,680 ft. and carried to a total depth of 4,085 ft. It proved to be less than one mile northwest of the present limits of the field.

During 1929, a reconnaissance core-drill survey was made by the Cities Service Oil Company in the Peace Creek area. Results of this work encouraged the company to conduct reflection seismograph surveys in the district. An extensive acreage acquisition program followed the combined exploration which was completed prior to 1936.

Cities Service then supported the drilling of a wildcat test offsetting its "A" block which was drilled by Albert M. Austin, Wichita, No. 1 Schwiethale. The Topeka lime was topped at 2,750 ft. (973 ft. subsea); the Lansing-Kansas City lime series at 3,250 ft. with a good showing of oil; the "Viola" lime at 3,625 ft.; the Simpson at 3,660 ft.; the reworked Arbuckle dolomite with oil stainings at 3,747 ft.; and the true Arbuckle dolomite at 3,750 ft. Drilling was carried 20 ft. into the Arbuckle dolomite to a total depth of 3,790 ft. where the test was abandoned as a dry hole. The Mississippian lime, the Kinderhook shale and the Fernvale member of the Viola lime, were absent in this well due to truncation. (See cross-section A–A'). Later drilling development proved this well to be situated approximately one and one-half miles too far west of the field. It was drilled on the basis of reflection seismograph evidence.

Discovery of the Zenith field in Stafford county in the "Misener" sand eight miles to the southwest resulted in Cities Service drilling their No. "A"-1 Kreie. This well proved to be located less than one-half mile southeast of the field's productive limits. This, too, was drilled on a reflection seismograph structure.

The same year another wildcat failure was drilled four miles south of the Kreie test by McCole et al. It was abandoned at a total depth of 4,084 feet in the Arbuckle dolomite as a dry hole.

The next wildcat test to be drilled in the Peace Creek area was that of Cities Service No. 1 C. C. Crandall. Good saturation was observed in a zone 12 feet below the top of the "Viola" limestone, the first oil showing to be logged in this formation in the immediate Peace Creek district. The "Viola" was later proven to be the principal producing pay in the field.

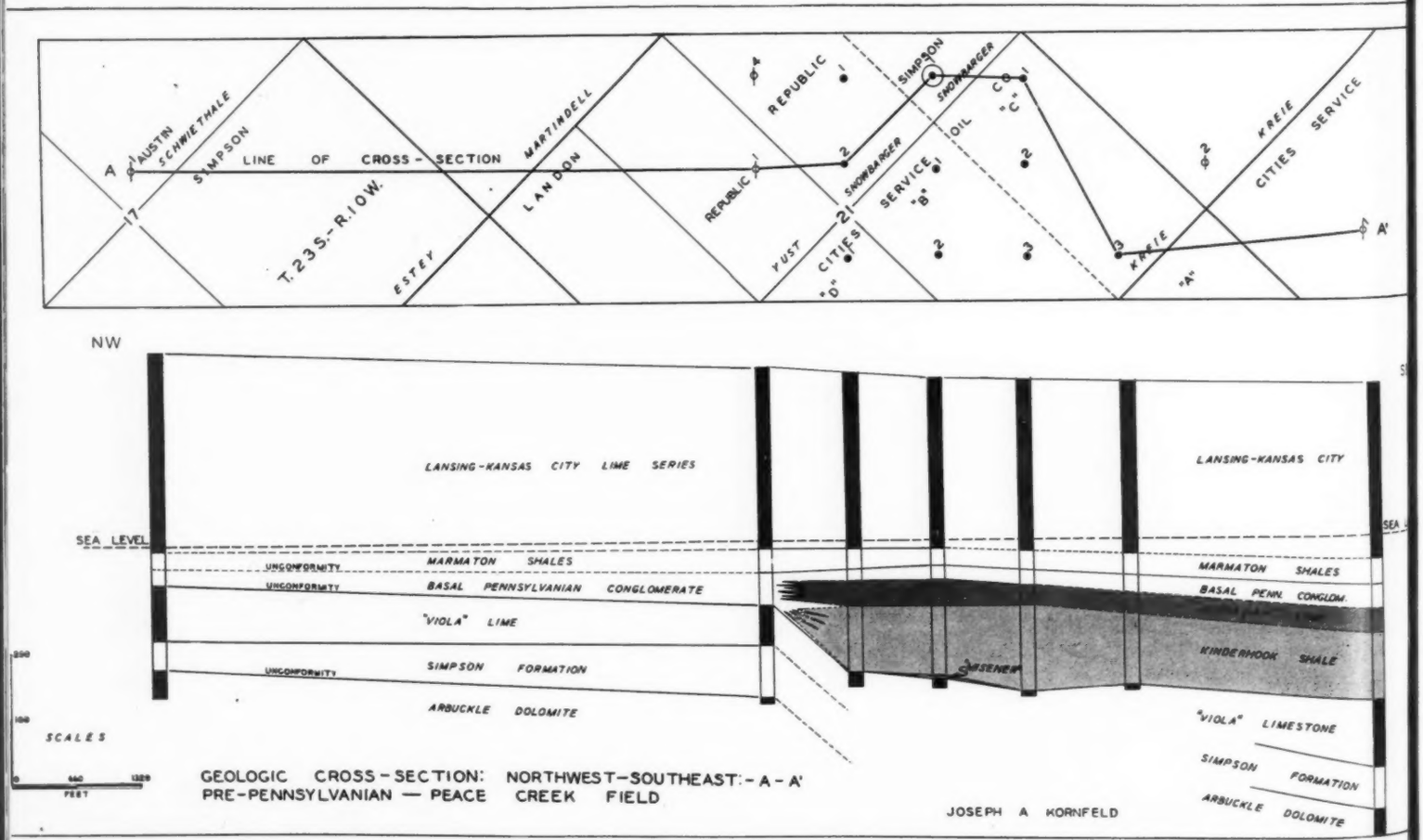
Formations logged in the Crandall wildcat included the Lansing-Kansas City lime series, the Mississippi lime, the Mississippian Kinderhook shale, the "Viola" limestone, the Simpson formation, and the Arbuckle dolomite. After the Arbuckle dolomite was penetrated only four feet, the test was completed as a dry hole. However, later development was to bring the productive limits of the field to within a diagonal offset of this failure. It marked the third test drilled in on the basis of reflection seismograph evidence.

Immediately upon completion of the Crandall test, Cities Service supported the drilling of another wildcat well in the same township, that of Simpson Oil Company, Witchita, No. 1 K. Snowbarger. The immediate basis of exploration that led to the field discovery was sub-surface geologic mapping, although the information drilled by the three prior exploratory wildcats on reflection seismograph pointed the way.

The Snowbarger test proved to be the discovery oil well for the field. "Viola" limestone, the producing formation, was topped at 3,775 ft. (1,994 ft. subsea). Casing was set and on initial flowing test, the well produced 125 barrels of oil per hour, natural. Gravity of the oil was 43 deg. A. P. I.

Table No. 1
Discovery Well of Peace Creek Field,
Surface Elevation 1,781 Ft. Dk. Fl.
Formation Markers
Simpson Oil Company No. 1 K.
Snowbarger
Southwest Southeast Northeast
Quarter
Section 21, Township 23 South,
Range 10 West
Reno County, Kansas

Formation	*Depth*	*Subsea*
Fort Riley limestone.....	1,715	....
Florence flint	1,798	17
Wreford limestone	1,880	99
Topeka limestone	2,840	1,059
Lansing-Kansas City lime.....	3,309	1,529
"Mississippi" limestone	3,620	1,839
Kinderhook shale	....	....
"Misener" sandstone	3,772	1,991
"Viola" limestone	3,775	1,994
Total depth in "Viola".....	3,789	2,008



DRILLING DEVELOPMENT

Drilling development spread rapidly upon completion of the Snowbarger discovery well. Within the first six weeks, four 3,000-barrel maximum size wells were brought in. Development consistently followed a 40-acre well spacing pattern. By the end of the year, 18 oil wells were completed, nearly all in the maximum well size range. Peace Creek Northeast, the second of a series of five discovery oil wells that eventually were joined by drilling to form the Greater Peace Creek field was that of Leader Oil Company, Tulsa, Okla., No. 1 A. Tonn, and one and three-fourths miles northeast of the Snowbarger discovery well. Subsurface geologic mapping was followed in staking the well. Placed on potential, it was completed for a 3,000-bbl. maximum well on December 23, 1941. The Nomenclature Committee of the Kansas Geological Society termed it the Peace Creek Northeast pool.

Meanwhile, two miles north of the Tonn discovery well, a third discovery well was in the making, N. Appleman, Central Petroleum Company, Wichita, and Iron Drilling Company's No. 1 Hendrickson. A 36-ft. section of "Fernvale" white, coarsely crystalline limestone was logged from 3,678 to 3,714 ft. the productive member of the "Viola" limestone formation throughout the field. The top of the cherty dolomite member of the "Viola" was found at 3,714 ft. (1,968 ft. subsea) and penetrated two feet and casing set. It drew an official state potential of 217 barrels of oil per day by pumping test and was completed on December 30, 1941. The field was named the Hendrickson by the Kansas Geological Society. Drilling development in the Hendrickson pool was favored by high regional structural position. Although the west offset proved dry, several other offsets were completed for maximum wells.

Schweizer, the fourth of the series of individual pool discoveries, later combined into the Greater Peace Creek field was drilled by N. Appleman & Company and Hinkle Oil Company, Wichita, No. 1 A. D. Schweizer, two miles northeast of the Hendrickson pool. Basis for staking this semi-wildcat was likewise subsurface geologic mapping. The top of the Topeka limestone was found at 2,735 ft. (1,009 ft. subsea); the Lansing-Kansas City lime series from 3,205 ft., the Misener sand lentil at 3,675 ft., and the "Fernvale" member of the Viola formation at 3,701 ft. First oil was logged at 3,721 ft., 53 ft. downdip from the Hendrickson discovery. Oil pay section was penetrated only four feet to 3,725 ft. where production casing was set. It drew an initial pumping potential of 774 barrels of oil per day as the discovery well of the Schweizer pool. Drilling development in this sector of the field proved to be disappointing from the standpoint of small well size potentials and proximity to the oil-water contact, at least one offset making water on initial completion. This sector did not extend more than one mile northward which marked the northern limits of what was to be later known as the Greater Peace Creek field.

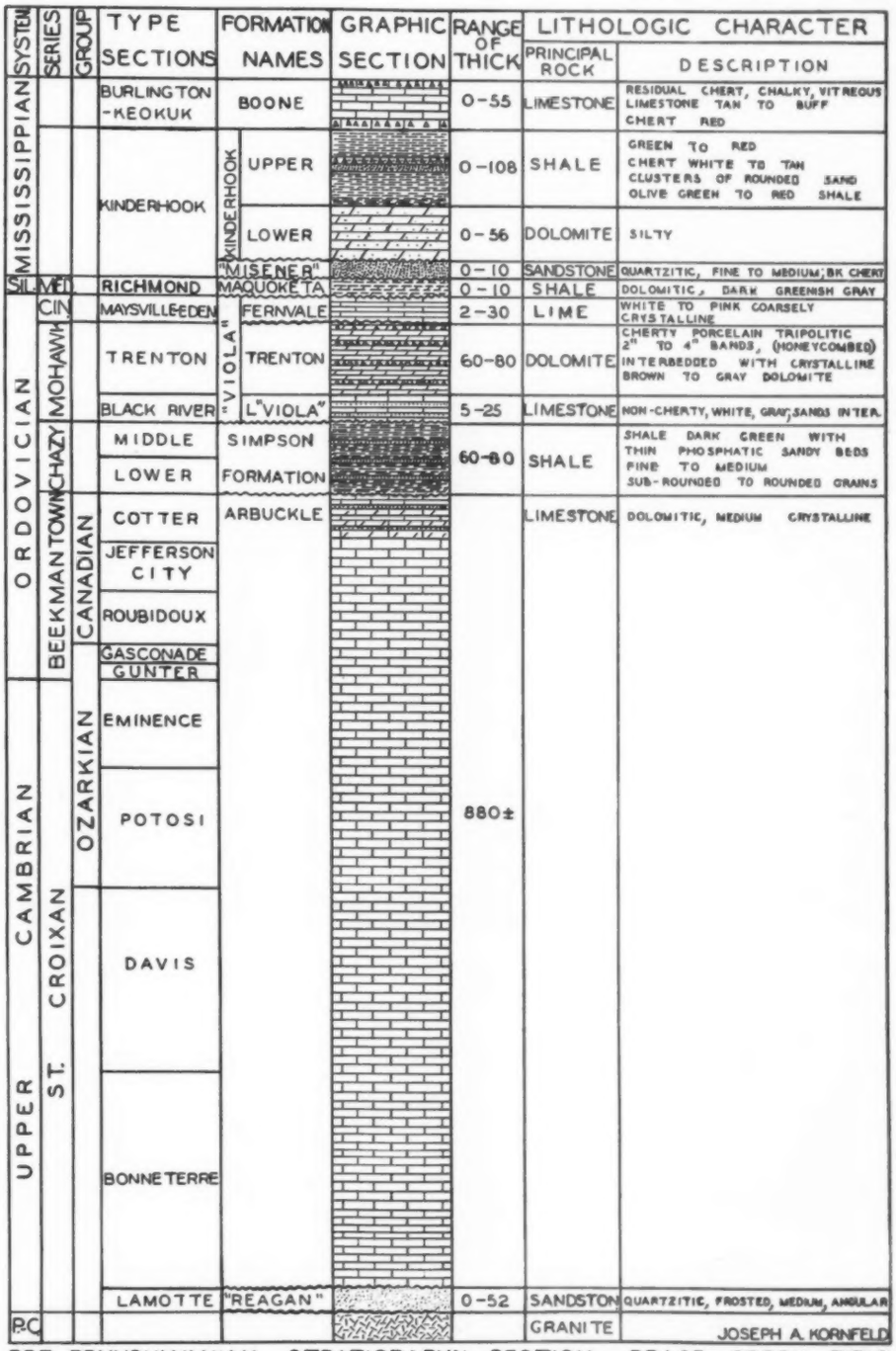
An attempt to extend the productive trend two and one-half miles northeastward proved a failure. No commercial oil showings were logged in drilling to a total depth of 3,830 ft., 33 feet in the Arbuckle dolomite.

Other unsuccessful attempts to extend the field northward were made by Helmerich & Payne, Inc., of Tulsa and Wichita, who drilled three dry holes, two to three and one-half miles north of the Schweizer pool.

Peace Creek Southwest was the fifth and last of the group of individual pool discoveries that were later consolidated into one reservoir. This well was drilled by the same operators who brought in the original pool discovery—Simpson Oil Company of Wichita. Their No. "B"-1 Souder was on acreage farmed out by the T. C. Johnson Estate of Wichita.

When it was started, the nearest developed oil production was one mile to the northeast. Basis of exploration was again subsurface geology. The "B"-1 Souder found the "Viola" limestone formation at 3,671 ft. (1,886 ft. subsea) more than 56 feet structurally higher than any of the other oil discovery wells. Later drilling development proved that No. "B"-1 Souder was drilled on the upthrown side of a normal fault which traverses the structure along a North-Northeast strike-line exhibiting a displacement of 130 feet. After acid treatments with 2,000 gallons, it drew a potential of 1,105 bbl. daily.

A second and deeper oil producing formation, the Arbuckle Dolomite, was discovered on November 1st in Southwestern portion of field on west upthrown side of fault by the Texas Company No. 2 Hornbaker Center west half northwest southeast section 32 ownship 23 south range 10.



PRE-PENNSYLVANIAN STRATIGRAPHY SECTION — PEACE CREEK FIELD

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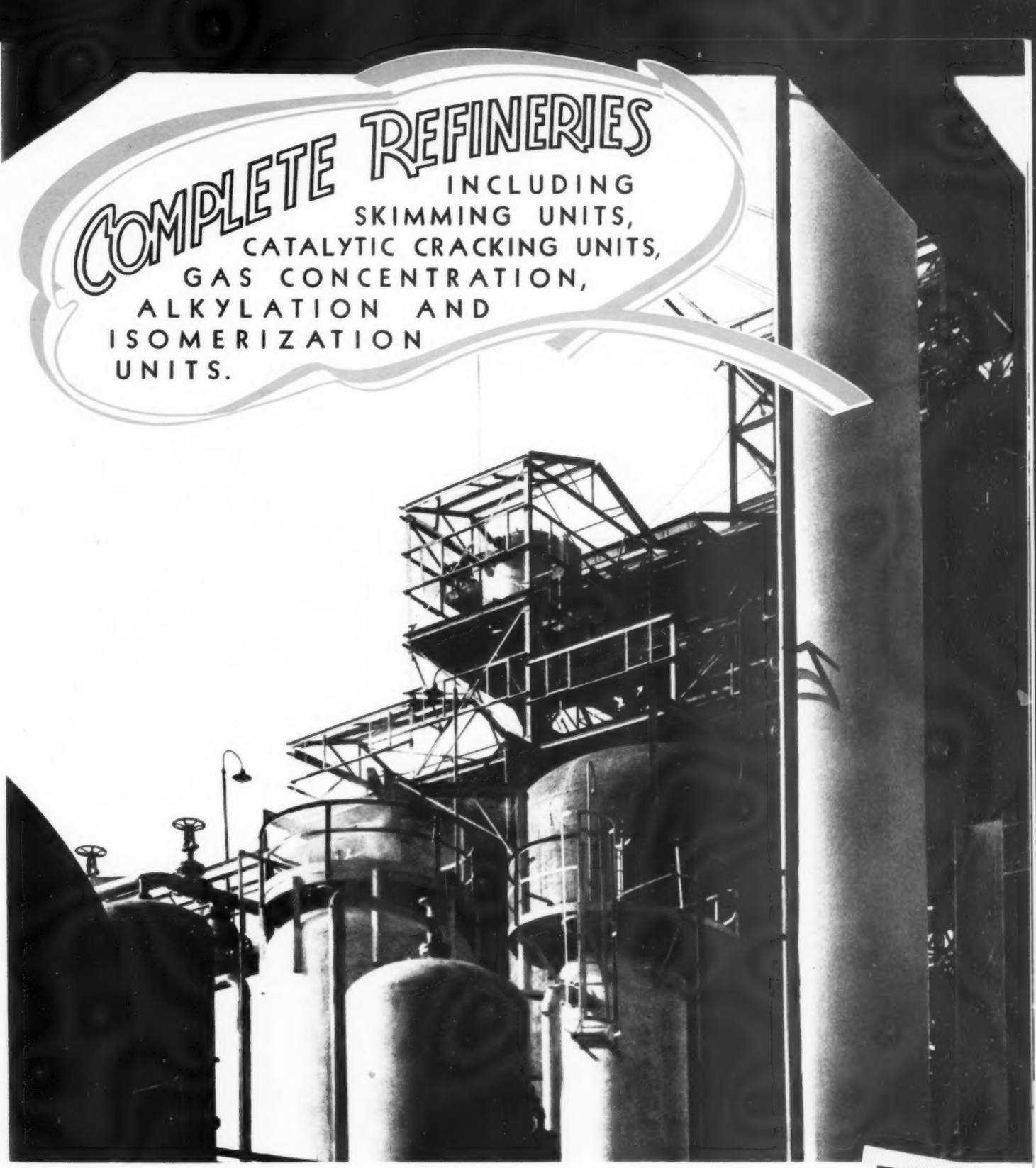

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ENGINEERING & CONSTRUCTION DIVISION

TULSA, OKLAHOMA

TABLE NO. 5—DISCOVERY OIL WELLS OF NORTHWESTERN RENO COUNTY, KANS

Original Pool Name	Discovery Operator	Name of Fee	Well No.	Description of Well Loca	Sec.	T	Rge.
Peace Creek	Simpson Oil Co.	K. Snowbarger	1	SW SE NE/4	21	2	10W
Peace Creek Northeast	Leader Oil Co.	Albert Tonn	1	SW SW SW/4	11	2	10W
Hendrickson	Central and Iron Drlg.	Hendrickson	1	CWL NW NE/4	2	2	10W
Schweizer	Central and Hinkle	A. D. Schweizer	1	SE SE NW/4	31	2	9W
Peace Creek Southwest	Simpson Oil Co.	J. R. Souder	B-1	SW NE NE	32	2	10W

The well filled 2,075 feet with oil and no water, following a one hour drill stem test with packer set at 3,722 feet on top of the Arbuckle 1,936 feet subsea.

Table No. 2

Number of Completed Wells

Source of Data: Kansas Corporation Commission, Conservation Division, Wichita, Kansas

(Discovery Date, July 30, 1941)

January 1, 1942	12 wells
July 1, 1942	73 wells
January 1, 1943	128 wells
July 1, 1943	137 wells
September 20, 1943	135 wells

STRUCTURE

Subsurface structure of the Peace Creek area is that of a monocline which dips southeast mainly at an average rate of about 25 feet to the mile. The structure is interrupted by a terrace occupying the northeast quadrant of T. 23 S., R. 10 W., and by a normal fault striking North-Northeast with a displacement of 130 ft. extending for a distance of 1½ miles in the southwest quadrant of the same township. Despite these structural features, the predominating feature of the accumulation of oil at Peace Creek is a variation in stratigraphy wherein portions of the two upper members of the "Viola" limestone formation have been removed by truncation and erosion and were overlapped successively by Silurian, Mississippian and basal Pennsylvanian strata. The stratigraphic trap conditions were not limited to the Peace Creek sector locally but were evident in a crescent extending from the Stafford townsite on the southwest to the town of Sterling on the northeast. The "Fernvale" member of the "Viola" limestone, which is the principal oil reservoir at Peace Creek, is removed by regional truncation and erosion progressively Northwestward, as was the overlying Maquoketa dolomitic shale and part of the underlying "Viola" cherty dolomite. Oil has been found on both sides of the normal fault described although the gas cap is confined to the upthrown side in certain sections.

The principal controlling factors in oil accumulation at Peace Creek are the absence or presence of the "Fernvale" member of the "Viola" formation accompanied by presence of porosity and permeability of that member. In general, oil production has been developed at subsea levels as high as 1,877 ft. in the southwestern corner of the field; oil pay has been commercially developed as low structurally as 2,020 ft. subsea, on the southeastern side of the field, thus marking a productive group of subsea elevations as shown in following table:

TABLE NO. 3

Subsea Productive Elevations

Sector of Field and Position	Highest	Lowest	Prod. Relief No. of Ft.
West of fault:			
Upthrown	1,877	1,886	9
East of fault:			
Downthrown ...	1,934	2,020	86

From the above table, it is evident that oil accumulation, while geographically continuous on both sides of the fault, is divided vertically into two sectors; that west of the fault and on its upthrown side displaying very slight relief, and that east of the fault and on its downthrown side exhibiting the normal productive relief based on regional position of the eroded, productive "Fernvale" member, of the "Viola" formation.

Commercial gas production has been developed from the upper part of the "Viola" formation only on the upthrown, westward side of the fault cutting the field. Gas has been logged in at least four wells.

The first completed gas well was the west offset to the "B"-1 Souder at The Texas Company's No. "B"-1 Hornbaker, where the top of the eroded "Viola" was logged at 1,837 ft. subsea, the highest gas well in the field, structurally. However, a second gas discovery was completed by Lion Oil Refining Company's No. 1 R. Yust, one mile to the north, which found the top of the eroded "Viola" at 3,635 ft. or 1,853 ft. subsea. It was completed on December 16, 1942 for an initial potential of 12,000,000 cubic feet of gas daily.

TABLE NO. 4

Stratigraphic Fields on Southeastern Flank of Central Kansas Uplift

Field and County	Producing Formation	Proven Acreage	Total No. of Wells	Estimated Ultimate Recovery
A. Oil Fields				
Peace Creek, Reno	Viola	6,880	237	29,033,000
Zenith, Stafford and Reno	Viola, "Misener" and Maquoketa	5,840	344	42,270,000
Stafford, Stafford	.....	560	21	3,880,000
Wherry, Rice	B. P. C.[1]	....	....	.....
Barnholdt, Rice, McPherson	Miss. Chat	....	....	
Welch, Rice	Miss. Chat	1,500	....	24,339,000
Smyres, Rice	Miss. Chat	920	23	.....
B. Gas Fields				
Wellman, Rice	"Misener"	640	10	.....
Hitz, Stafford	Maquoketa	160	1	.....

BINED TO FORM PEACE CREEK FIELD (SUBSEQUENT DRILLING UNITED INTERVENING AREAS)

Rge.	Date of Completion	Completion Potential (B.O.P.D.)	Type of Potential	Gravity of Oil Deg. Bé.	Producing Formation		Method of Discovery
					Name of Pay	Top of Viola (Subsea)	
10W	July 29, '41	7,510	Draw-Down	43	"Viola" LS.	—1994	Subsurface
10W	Dec. 23, '41	3,000*	Draw-Down	43° @ 80°	"Viola" LS.	—1992	Sursurface
10W	Dec. 30, '41	217	Pumping	....	"Viola" LS.	—1934	Sursurface
9W	Feb. 5, '42	774	Pumping	36.[2]	"Viola" LS.	—1975	Subsurface
10W	June 1, '42	1,102	Bottom-Hole Pressure	....	"Viola" LS.	—1886	Subsurface

ximum Potential Allotment by Rules and Regulations of Kansas Corporation Commission

WELL COMPLETION PRACTICES

The most common method for completing oil wells at Peace Creek employs the setting of casing on top of the "Viola" lime where it is cemented. The top of the "Viola" is determined by drilling-time and by coring. After the customary 72-hr. time lag allowed for the cement to set, cement plug is drilled out and the hole loaded with a cushion of 1,000 ft. of fresh water in the more prolific sectors of the field. When the maximum pay section penetration is reached as indicated by maximum fillup, the hole is bailed down and the well allowed to clean itself into mud pits if the flow is sufficiently great. Otherwise, the well is swabbed, and placed on the pump. Nearly all wells are acidized after initial completion and potential.

In the southwestern corner of the field where gas under high pressures is logged in the upper part of the "Viola" formation, the gas section is mudded off and drilled through, pipe set through the oil pay and gun-perforated with about 10 shots to each feet of pay section, and completed through casing perforations. In the same sector, wells intended for gas completions are drilled through the entire series to the Arbuckle dolomite, Schlumberger electric well log surveyed, the hole plugged back to the Simpson and the pipe set through the gas pay and then gun-perforated for completion.

General field practice calls for the taking of a temporary or swabbing potential, usually 50 barrels when the well is initially tested. When the well is completed initially, another potential is taken natural, by physical pumping test based on an 8-hr. period, or by indicated productivity as shown by the use of bottom-hole pressure bombs or Depthograph or Echometer which registers the productivity from the rate of fillup.

CASING PRACTICE

Casing practice employed at Peace Creek comprises the use of only two strings of casing. The surface string is 8⅝-in. or 10-in. O. D. set to an average depth of about 285 feet and cemented. The production string is usually 5½-in. set at about 3,800 feet. Pipe is usually landed on top of the "Viola" formation unless the well is carried through the gas cap, in which case pipe is set through the oil pay and gun-perforated.

Casing practice followed by Skelly Oil Company calls for setting 10-in. O. D. pipe set at a depth of 273 ft. and a 6-in. production string set at about 3,700 ft. (in the southwestern corner of the field.)

OPERATING COMPANIES

Companies operating properties at Peace Creek include Cities Service Oil Company, (the largest from the standpoint both of number of wells and productive acreage), Republic Natural Gas company, Magnolia Petroleum company, Derby Oil company, Simpson & Noble, Sinclair Prairie Oil company, Transwestern Oil company, Mid-Continent Petroleum corporation, Stanolind Oil and Gas Company, Barnsdall Oil company, Lion Oil Refining company, Auto Ordnance, Inc., Carter Oil company, The Texas Company, W. E. Porter et al, Iron Drilling company, N. Appleman and Company. Carter Oil Company, a producing subsidiary of the Standard Oil Company of New Jersey, entered the field during 1942.

STRATIGRAPHY: PRE-CAMBRIAN

The only test in the immediate vicinity of the Peace Creek field which reached the pre-Cambrian rocks is that located approximately three and one-half miles southwest of the pool proper in the Zenith area. This well, a salt water disposal test, was drilled by Sinclair Prairie Oil Company. Top of the pre-Cambrian granite was logged at a depth of 4,714 feet.

CAMBRIAN

REAGAN. The presence of 52 feet of "Reagan" sand of upper Cambrian age is indicated in a deep test drilled 11 miles northwest of the field, where it lies unconformably on pre-Cambrian granite in place. The "Reagan", as shown in microscopic well cuttings from wells taken on the Central Kansas uplift, is an angular, medium-grained, frosted, quartzitic sand.

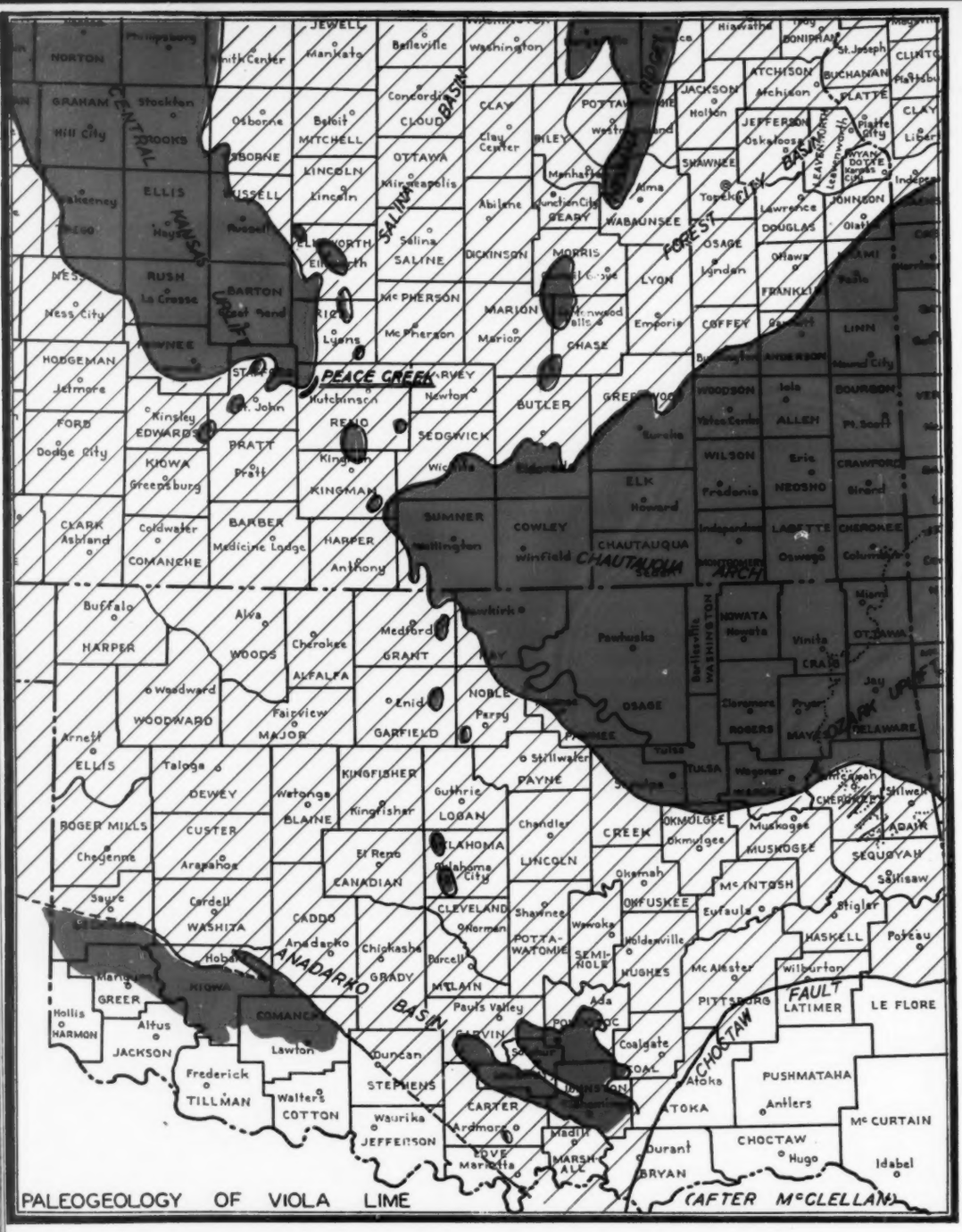
CAMBRO-ORDOVICIAN

ARBUCKLE. The Arbuckle dolomite of upper Cambrian and lower Ordovician age lies unconformably upon the "Reagan" sand. Only one well has drilled through the entire section of Arbuckle dolomite in the Peace Creek district, Sinclair Prairie's No. 1 McComb. One salt water disposal well drilled in the heart of the Peace Creek field stopped at a 174-ft. penetration of Arbuckle dolomite before it was completed. In general, the Arbuckle is fine to coarse crystalline dolomite, containing zones of colitic chert. Productive Arbuckle on the Central Kansas Uplift are Cotter and Jefferson City correlatives of the Ozark type section.

ORDOVICIAN

SIMPSON. Unconformably overlying the Arbuckle dolomite is the Simpson formation. In the Peace Creek area, it is composed of red and gray and green shales with thin zones of hard gray cemented calcareous sands and white and grey sand clusters. It carries occasional grey dense crystalline lime streaks and grey sandy micaceous shale. Thickness in this field varies from 60 to 80 feet. It is correlated with the lower and middle Chazy of the New York type section of the Ordovician system.

"VIOLA". The "Viola" formation unconformably overlies the Simpson at Peace Creek. In this field, it is comprised of three members, a basal limestone member, 5 to 25 ft. thick, composed of white, grey, non-cherty limestone with interbedded sands; a middle cherty dolomite member, 60 to 80 ft. thick, comprising brown to grey, crystalline dolomite, interbedded with 2 to 4-in. bands of honeycombed, tripolitic porcelain chert; an upper member of "Fernvale" limestone, 2 to 30 ft. thick, comprised of white to pink, coarsely-crystalline limestone. As to correlations, the lower member is Black River, the middle member is Trenton, and the upper member is generally conceded to be of Maysville-Eden in the Cincinnatian series of the Ordovician system. The "Fernvale"



Regional Paleogeology of "Viola" Line. Areas Underlain by "Viola" in Blue; Regional Uplifts in Red.

and parts of the cherty dolomite members are truncated and eroded away updip.

SILURIAN

MAQUOKETA. A thin layer of Maquoketa shale has been reliably logged in several wells drilled in the southwestern corner of the field. The Maquoketa unconformably overlies the "Fernvale". It is a dark to light greenish-gray, dolomitic shale. However, it is generally absent over most of the Peace Creek field, probably due to erosion rather than to non-deposition. It is correlated with the Richmond beds of Medinan age in the type section.

MISSISSIPPIAN

"MISENER". Unconformably overlying the "Viola" formation at Peace Creek are thin sand lenses of unconformity sands known in oil-field nomenclature as "Misener" named after F. D. Misener of Tulsa, Oklahoma who first discovered commercial oil accumulations in similiar deposits in eastern Oklahoma. Occurring irregularly as beach sands and off-shore sand bars in the lower Mississippian, it is lithologically a fine to medium, quartzitic sandstone containing black chert. In the Peace Creek field, it occurs as thin beds of sandstone intercalated in the lower sandy green shales of the Kinderhook.

KINDERHOOK. The Kinderhook formation in the Peace Creek area is comprised of a lower, silty dolomite, 0 to 56 ft. thick found in the northeastern corner of the field, and an upper shale bed, 0 to 108 ft. thick, comprised of green to red shale and containing white to tan chert and clusters of rounded sand. The upper shale member has been logged in nearly all wells drilled in the field. The Kinderhook shale thickens to the southeast, attaining a maximum interval of 131 feet in the southeastern corner of the field. As much as 164 feet of Kinderhook section has been logged at a dry hole drilled two miles east of the field at Hollow Drilling Company's No. 1 J. T. Wilson. The Kinderhook is absent in Lion Oil Refining Company's No. 1 Yust, where the Basal Pennsylvanian Conglomerate is in unconformably contact with the "Viola" formation. Along the northwest side of the field, the Kinderhook is overlain by the Basal Pennsylvanian Conglomerate. Elsewhere to the southeast, it is covered by the "Mississippi" lime. It is separated by angular unconformities between the underlying Viola limestone (and Maquoketa shale where present) and between the overlying Basal Pennsylvanian Conglomerate.

"MISSISSIPPI" LIME. Throughout nearly all of the producing sectors of the Peace Creek field is found a thin section of "Mississippi" limestone which varies from 0 to 55 feet in thickness. It is essentially a chalky, residual chert but elsewhere to the northeast it contains zones of tan to buff limstone and red chert at its base. It is correlated with the Boone of the St. Joe series of the lower Osage.

STRUCTURAL HISTORY LOWER PALEOZOIC

The Paleozoic structural history of the Peace Creek pool was affected by at least three periods of adjustment;

(1) the post-Arbuckle-pre-Simpson;
(2) the post-Maquoketa-pre-Kinderhook; and the
(3) post "Mississippi" lime-pre Basal Pennsylvanian conglomerate.

Sequence of Sedimentation. Following the de-

Joseph A. Kornfeld.

position of the Jefferson City and Cotter members of the thick, Cambro-Ordovician Arbuckle dolomite, widespread regional truncation occurred over the Central Kansas Uplift. After a hiatus of long duration, characterized by base-levelling, the Ordovician seas invaded the area and deposited a series of Ordovician sands, dolomites and shales around the rim of the Central Kansas uplift. The "Viola" limestones were laid down with fairly regular succession over the Simpson formation. A major structural disturbance followed with the erosion of the upper portion of the "Viola" limestones. The Maquoketa dolomite which had been laid down across most of the Peace Creek district was removed by erosion. Thin beds of "Misener" sands were laid down over the eroded surface of the "Viola" lime series. Rapid submergence preceded the deposition of the Mississippian. (The Kinderhook was laid down in quiet non-turbulent marine waters as shown by the presence of well-preserved plant spores and Mississippian conodonts). This was followed by deposition of residual beds of Mississippian Osage age, principally residual chert from higher elevations. The next significant structural event was the base-levelling of the now-prominent Central Kansas uplift allowing deposition of vari-colored cherty basal Pennsylvanian conglomerate over the now-based-levelled area including Peace Creek.

Another period of submergence brought interrupted deposition of vari-colored shales in the overlying Marmaton formation which initiated Pennsylvanian sedimentation.

STATISTICS FOR PEACE CREEK FIELD

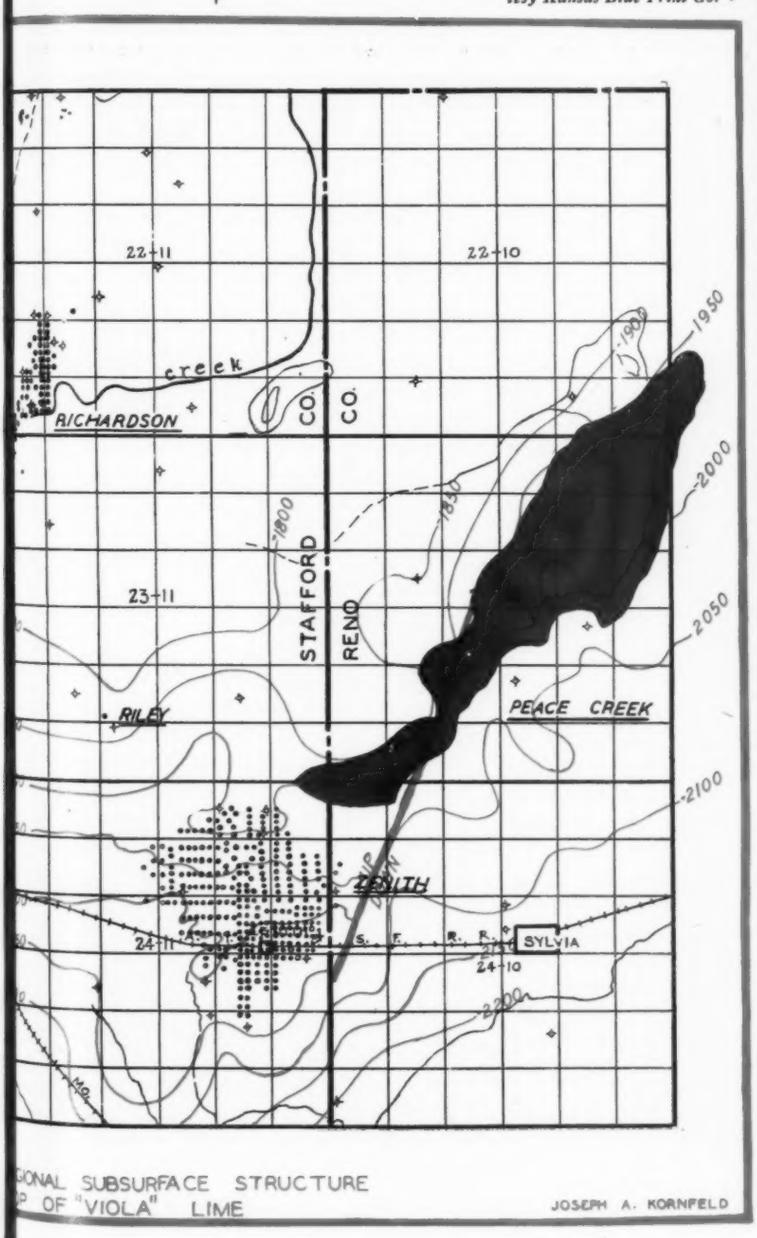
Average depth of all holes drilled.....3,800
Number of producing oil wells (October 20, 1943) 237
Deepest hole drilled (Cities Service No. 3 Estey) 4,000
Deepest formation tested in field proper..Arbuckle
Amount of acreage in proved area.....6,880
Length of producing area .....10 miles
Width of producing area.....1 to 2 miles
Gravity of crude oil:
Viola lime reservoir.....36 to 43 deg. B
Location of field:
Townships 22 to 23S., Ranges 9 to 10 W.
Discovery date of field.....July 30, 1941
Accumulative production:
(Jan. 1, 1943).....1,557,973 bbl.

ANALYSIS BY POOLS

Peace Creek	772,732
Peace Creek N. E.....	466,539
Hendrickson	..294,717
Schweizer	16,750
Peace Creek S. W.	7,235
Combined areas	1,557,973

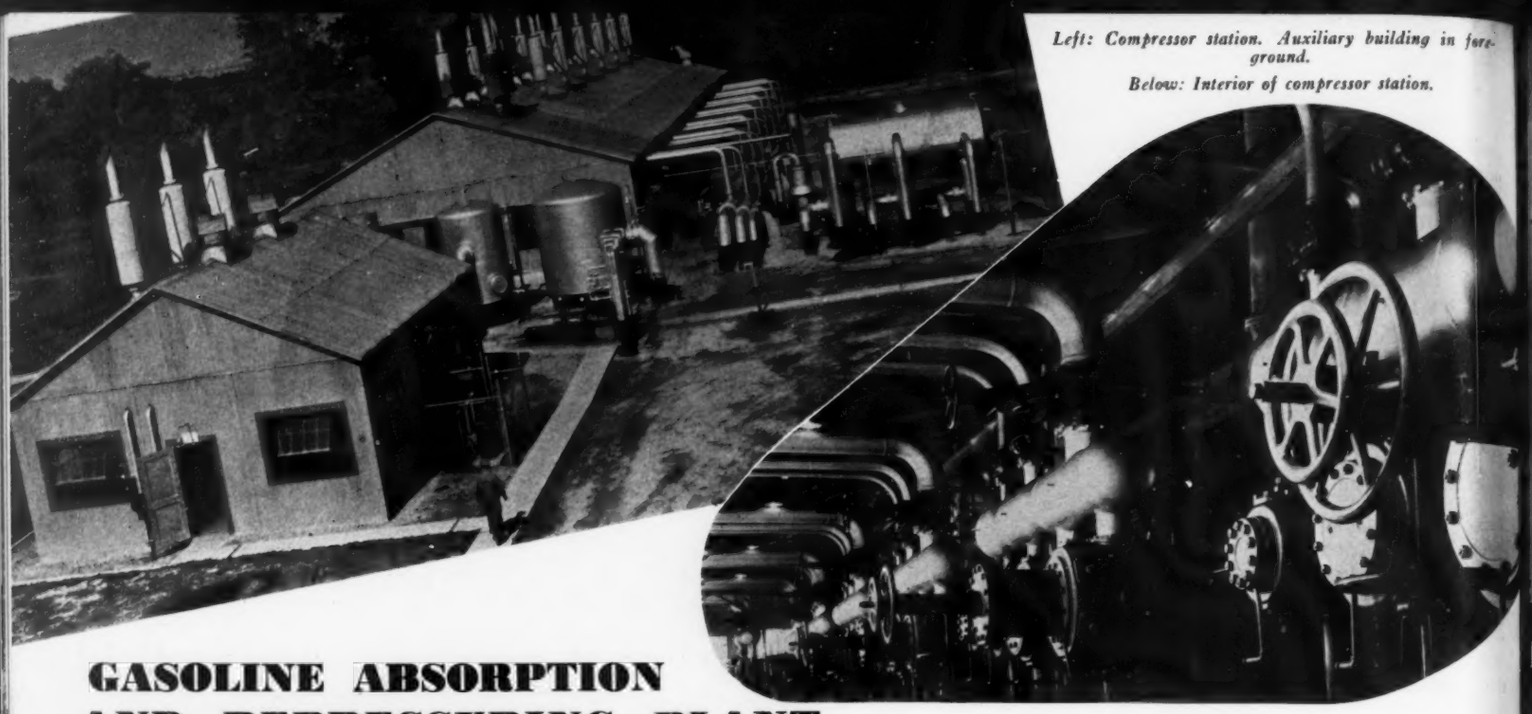
Relationship of Structure to Oil Production.

Eroded "Viola" Line Shown in Blue; Overlying Kinderhook Shale in Half-black; Mississippi Lime in Red. Base Map Courtesy Kansas Blue Print Co.



ONAL SUBSURFACE STRUCTURE
P OF "VIOLA" LIME

JOSEPH A. KORNFELD



Left: Compressor station. Auxiliary building in foreground.

Below: Interior of compressor station.

GASOLINE ABSORPTION AND REPRESSURING PLANT

By R. P. Mase and N. C. Turner*

Combination System at Crossville, Ill., Includes Two Compressor Stations with Single Distillation Unit—Processes 20,000,000 Cubic Feet Daily with 14,000,000 Returned for Pressure Maintenance.

A COMBINED repressuring system and gasoline absorption plant recently completed by Warren Petroleum Corporation and the producers in the Crossville, Illinois, area incorporates several advanced features tending to efficient and economical operation. The fields served by this unit are Calvin and New Harmony which are west of the Wabash River, and Griffin field which is east of the Wabash River. These areas are normal oil production fields rather than distillate fields. The project is one of the largest repressuring plants in the country of this type and handles approximately 20 million feet per day of green gas, of which 14 million cubic feet per day comes from the absorbers as residue gas for return to pressure maintenance operations. The natural gasoline plant is operated by Warren Petroleum Corporation. Pressure maintenance operation is under supervision of an engineer representing the Repressuring Committee.

The larger fields, namely Calvin and New Harmony west of the river, are located six miles from the Griffin field east of the river. In order to reduce the size of the gathering system the compressor installation was divided into two stations. One, a 4000 horsepower station, handles gas from the Calvin-New Harmony fields and is located near Crossville; the other is a 2400 horsepower station located in the Griffin field. The distillation unit and hydro-carbon fractionating system are centralized and are located in conjunction with the Calvin-New Harmony compressor station. A remote absorber handles the gas from the Griffin station and is located close to it. Lean oil is pumped to this absorber from the Calvin-New Harmony plant and the fat oil returns under this absorber pressure. This arrangement makes possible the use of a single distillation and fractionating system to handle the products from both plants. Since a fractionating system required to produce the number of products required in this plant is of necessity somewhat complex, the advantages of a centralized system both from a standpoint of first cost and operation are obvious.

The gathering and return systems were laid almost wholly in the flood area of the Wabash River Valley. For this reason it was necessary to anchor all pipe lines larger than six inches in size. Due to the presence of numerous lagoons and by-pass channels a large number of suspended pipe line crossings were required. The gathering and return systems for this plant consist of over 200 miles of pipe lines varying in size from two inches to twenty-four inches. Because of the probability of floods, the Crossville plant, consisting of the main compressor station as well as the gasoline plant, was erected on an escarpment approximately one hundred feet above the Wabash River valley.

In order to return the residue gas directly to the field, the compressor stations are set up to compress the gas to required pressure for gas maintenance before introducing it to absorbers. A considerable portion of the absorption gasoline and lighter products are condensed by compression and subsequent cooling. This unstabilized material in case of the remote Griffin plant is introduced into the fat oil line down-stream from the absorber. In the case of the Crossville plant the unstabilized compressor condensate is handled through a vent system and from there is pumped directly to the absorption gasoline stabilizer.

Absorber pressure at Griffin is approximately 700 pounds, while at Crossville, absorber pressure is approximately 600 pounds. These pressures are sufficient to reinject the gas to the producing strata. Residue gas is dehydrated as it comes from both absorbers in order to prevent hydrate formation in return lines and control equipment. Florite solid absorbent system is used.

Analysis of "Green Gas" is as follows:

	Mol Per Cent
C_1	64.42
C_2	14.28
C_3	11.06
I-C_4	1.16
N-C_4	5.09
I-C_5	.95
N-C_5	1.28
C_6	1.76

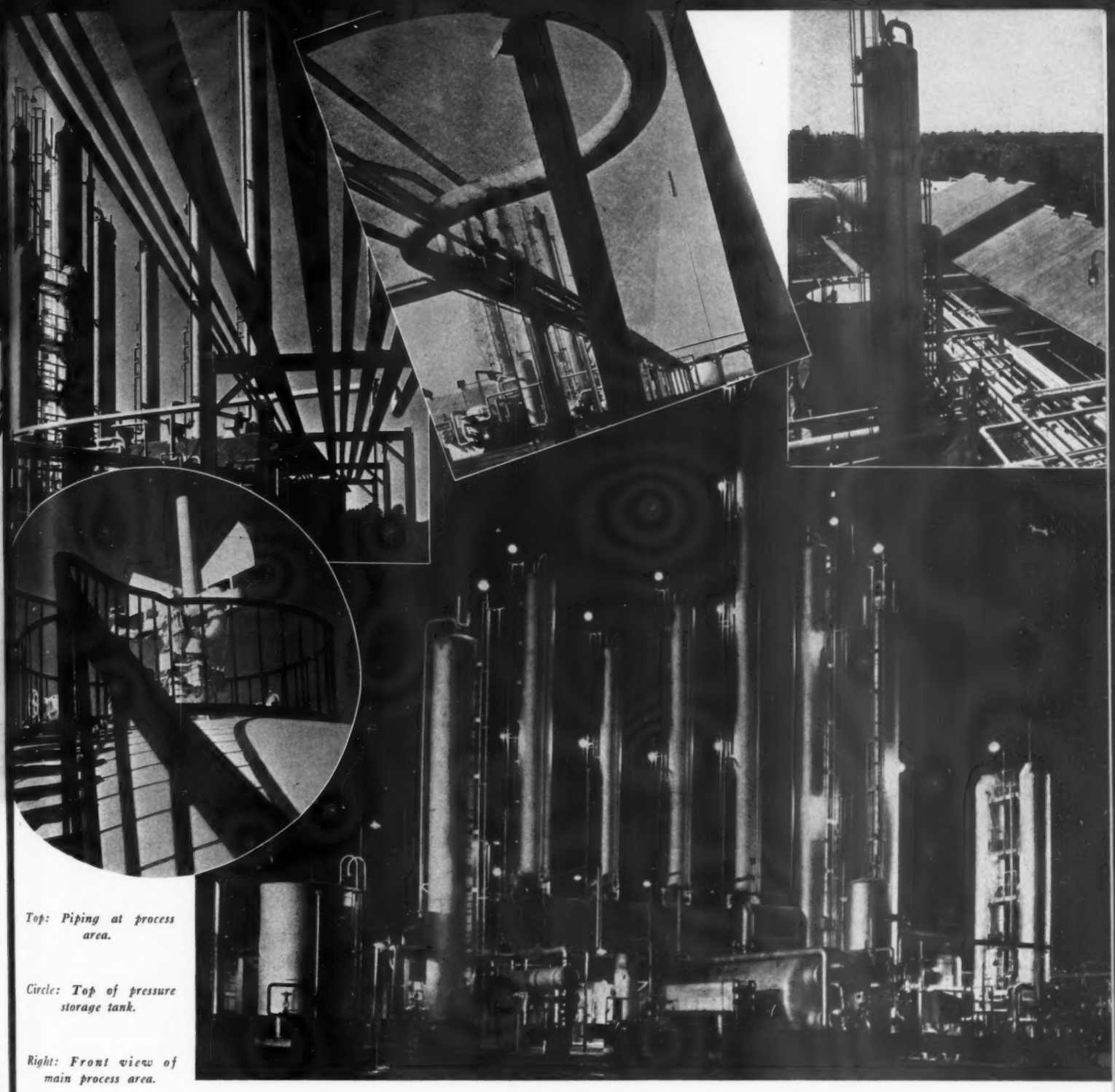
Analysis of residue gas returning to field:

	Mol Per Cent
C_1	76.81
C_2	14.90
C_3	8.13
I-C_4	.16

The distillation system of the gasoline plant is conventional except that stabilization of fat oil and reabsorption of all vent vapors is carried out in a single unit, which derives its heat from heat exchange. Stabilized fat oil then passes to a conventional stripping still. The combination fat oil stabilizer and reabsorption operation simplifies the operation of the unit since no tail gas compressor is required. It also appreciably reduces the amount of ethane to be handled in the subsequent fractionating equipment. This in turn reduces the loss of propane since as mentioned below the propane loss is approximately proportional to the ethane removed where a refrigerated reflux condenser is not used. At the same time operation of the unit is very flexible.

All unstabilized absorption gasoline along with butane, propane and lighter liquid constituents

* Chief Engineer & Process Engineer Frick-Reid Supply Corporation



Top: Piping at process area.

Circle: Top of pressure storage tank.

Right: Front view of main process area.

Photos by C. Dudley Johnston for Frick-Reid Supply Company.

Top Center: Piping at Crossville plant.

Top Right: Pipes and storage at Crossville.

are pumped to the first of a four-column stabilizing system. No. 1 fractionating column produces from the base finished absorption gasoline of desired vapor pressure ranging from 12 pounds to 26 pounds under operator's control. Overhead product from the No. 1 column is condensed and accumulated for feed to the No. 2 column. This feed contains all butanes in excess of that required for absorption gasoline, along with propane and such lighter constituents as are not completely removed by the fat oil stabilizing unit.

Base product from the No. 2 column consists of a butane propane mixture. The overhead product from this column contains all ethane and lighter elements along with such propane as is lost incidental to operation without benefit of a refrigerated reflux condenser. This is discarded to fuel.

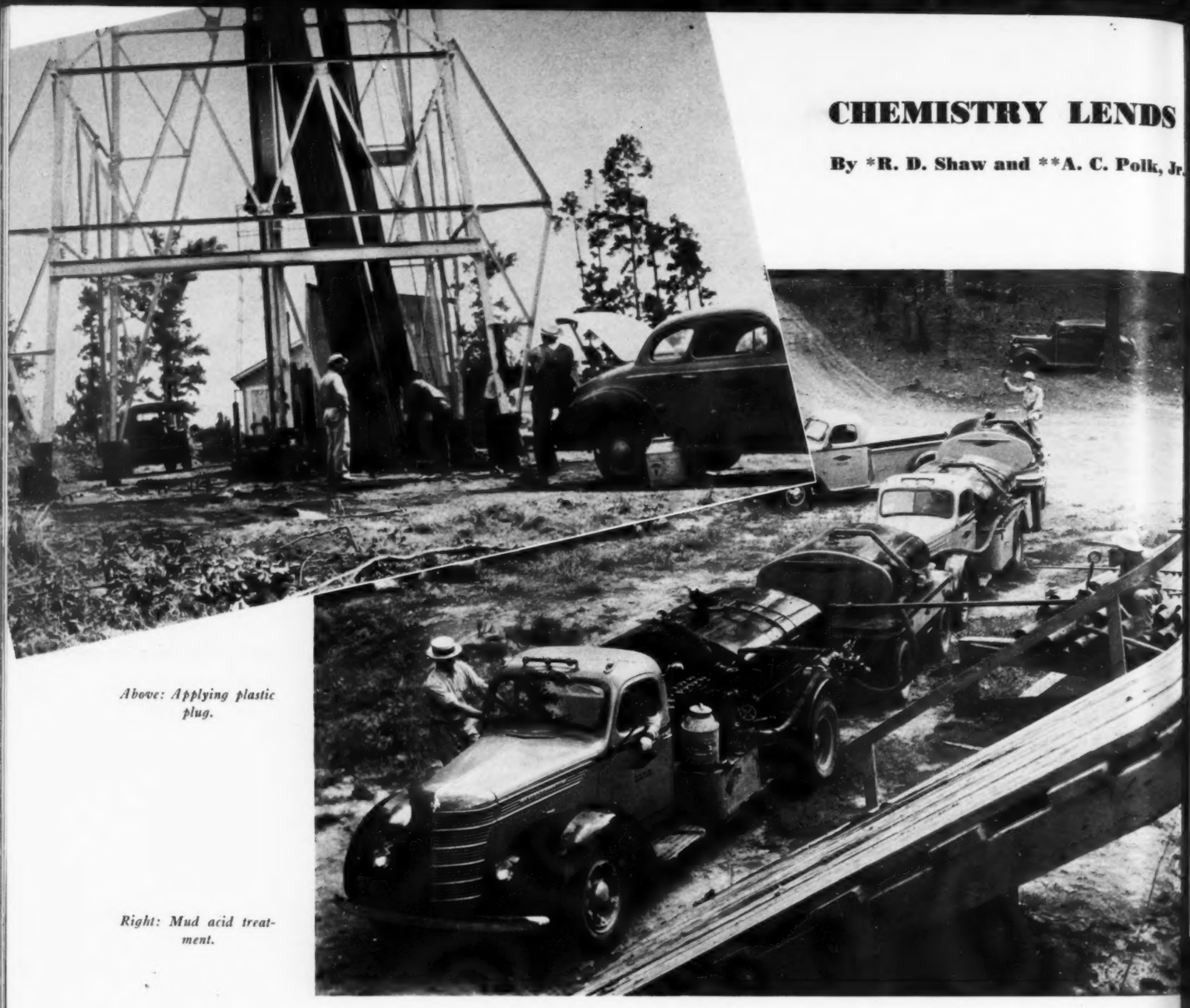
Base product from the No. 2 column, consisting as above stated of butanes and propane, becomes feed to No. 3 column. In this system mixed butanes are recovered from the base, while commercial propane is recovered overhead. Mixed butanes from the base of No. 3 column become feed to No. 4 column. Iso-butane passes overhead, while normal butane is taken from the base.

Absorption gasoline coming from base No. 1 column is Perco sweetened. Base product from No. 2 column consisting of butanes and propane is caustic washed. Propane, iso-butane and normal butane recovered from No. 3 and No. 4 columns do not require further treatment.

Plant design and construction of Crossville compressor station and gasoline plant was furnished by Engineering and Construction Division, Frick-Reid Supply Corporation, working in conjunction with engineering and operating force of Warren Petroleum Corporation.

CHEMISTRY LENDS

By *R. D. Shaw and **A. C. Polk, Jr.



Above: Applying plastic plug.

Right: Mud acid treatment.

MOST important of the problems facing the petroleum industry today is how to secure from existing wells the crude required to meet the constantly increasing demands of military and essential civilian consumers. The wells now being completed do not provide sufficient oil to offset the decline of the present producers. As a result of this situation the industry is giving greater attention to technical developments which will improve the production efficiency of existing wells, thus promoting the economic recovery of the greatest possible percentage of the oil in place in the reservoir.

This trend toward engineered reconditioning of marginal and submarginal wells involves various techniques, some of which may be entirely mechanical, while others may utilize the knowledge, materials and methods of the chemical engineer.

* Sales Manager, Dowell Inc.
** Development Engineer, Dowell Inc.

The application of chemicals to wells in order to improve their productive characteristics has long since become an established progressive force in the business of producing oil. The economic advantages derived from the acid treatment of wells producing from reservoirs composed essentially of limestone is so well known that further discussion is unnecessary. However, the successful chemical treating and reconditioning of this type of wells has furnished the basis for the introduction of numerous addition agents, special types of equipment and improved techniques that have resulted in the expansion of chemical well treating to include wells producing from all types of formations.

Very early in the development of the acidizing industry certain problems were encountered that indicated the need for suitable addition agents to solve or minimize these treating difficulties. One of the most troublesome problems was the complete and rapid removal of the spent acid products which tended to cause an appreciable amount of plugging of the pores, thus offsetting the advantages to be gained from acidizing unless they could be removed. In low pressure reservoirs this problem was paramount because of the high viscosity of the reaction products and the pressure available in the reservoir to effect their expulsion. Another problem involved the reduction of the pressures required to force the treating compounds into the saturated zones of very low permeability.

The solution of both of these problems was secured by the use of suitable surface tension depressants which, when added to the acid solution, caused a sufficient reduction in the surface tension of the treating chemicals so that the reaction products moved freely through the formation. These same agents permitted the treating chemicals to enter the zones of low permeability at substantially lower pressures.

The use of these low surface tension chemicals produced successful results in many low pressure

HAND TO THE OILFIELD ENGINEER

Provides Effective and Economical Means of Reconditioning Wells—Development of New Methods and Equipment Makes it Possible to Deal with Variety of Conditions that Impair Productivity.

areas in which all previous attempts to recondition chemically had failed. Low surface tension acid also made possible the treating of wells completed in sand formations, as the acid could be injected, at minimum pressures, into this type of formation despite low initial permeability and porosity.

The large scale laboratory studies of cores which accompanied the expansion of the chemical treating of wells completed in sands revealed that, although all of the acid soluble carbonates were being removed effectively, an appreciable percentage of clay-like compounds, indigenous to the formation, plus quantities of drilling fluids, which entered the sands during drilling, were being left intact and causing a considerable amount of plugging of the pores. It followed, therefore, that the economical results secured by the use of low surface tension acid on sands were due only to the removal of the carbonates present as pore blocking or cementing material.

In order to improve the results secured from the use of acid on sand it became apparent that other addition agents had to be found that would cause the dissolution or disintegration and removal of these clay-like particles and mud sheaths. The continued study of these problems resulted in the introduction of mud acid, a combination of low-surface tension acid and addition agent capable of attacking and effecting the removal of these normally insoluble pore-blocking compounds.

The experience gained from the use of this type of treating compound in wells completed in sand formations and in wells where infiltered drilling fluids have caused producing difficulties has established its economic value as a reconditioning procedure.

The further analyses of reconditioning problems revealed that numerous wells were declining much too rapidly. Upon examination it was discovered that accumulations of paraffin or wax deposits were sealing off the productive formation and lowering the efficiency of the bottom hole equipment and tubing to the extent that only a minimum amount of production was permitted to enter the well bore and move to the surface. A combination of laboratory and field work developed suitable solvents, field testing apparatus for the selection of the proper solvent, and methods of application to correct economically the numerous conditions encountered. The value of paraffin solvents is governed entirely by proper diagnosis, followed by the engineered application of the selected solvent. The chemical removal of this sealing material restores the production to a normal status; therefore, it becomes evident that periodic chemical cleaning of this type is very sound practice.

The expanding use of chemicals in wells was accompanied by an increase in the number and complexity of production problems encountered. The most common of these problems was the control of the chemicals during application so that they entered the desired zone. The use of jelly seal was an early step in acid control by chemical means. Jelly seal is an organic chemical solution which remains in a fluid state until applied to the proper point in the well where it sets into an impermeable gelatinous mass incapable of further movement except under very high pressures. This organic compound was used widely to block off undesirable sections in the bottom of wells. This product made possible the treatment of many types of wells which would not ordinarily respond to chemical applications.

After the jelly seal has served its purpose bacteria, which were introduced prior to its application to the well, digested the jelly, causing it to return to a liquid state and thus facilitating its removal along with the other fluids produced from the well.

The chemical reconditioning of wells which were completed in sections of varying permeability or multiple productive zones, one or more of which had been previously acidized, presented the need for additional knowledge as to the distribution of permeability throughout the entire productive sections. This information would allow the engineer to secure greater efficiency from the chemical treatment as a more specific diagnosis could be made. To obtain this information the electric pilot was introduced. After applying the electric pilot to field problems, it was found that in addition to furnishing the desired information, it also afforded a method of absolute, positive control during the introduction of chemical treating agents.

The electric pilot is an instrument which utilizes an electrical current in connection with two injected fluids, one a conductor and one a nonconductor of electricity, to determine accurately the interface between the two fluids. The accurate location of the fluid interface accomplishes five major functions: (1) To determine relative permeability of the formation in place; (2) to spot or locate acid at any desired depth or for controlled use in any selected zone in the producing formation; (3) to find the top of mud or other chemical bridges; (4) to re-locate lost cas-

Acid deepening equipment in operation.

ing points or tubing bottom; and (5) to determine the location of casing leaks. The abundant information supplied by the electric pilot makes this service almost an economic necessity on any work-over job. It is now possible to acidize selectively a producing formation and direct the acid into the less permeable zones so that uniform permeability throughout the section can be established. Therefore successful reconditioning is now an actuality in old wells that, due to inadequate application methods, were approaching abandonment.

Some of the types of wells wherein the electric pilot has proved most beneficial are: wells with extended productive sections exposed; wells with two or more producing pay zones; wells requiring reacidizing; wells which have been deepened or plugged back to new horizons; wells which have a sand formation exposed above or below limestone formation; wells producing excessive quantities of gas or water. These services, as applied to reconditioning, cause the economic value of this instrument to be readily acceptable. During any reconditioning program, it occasionally becomes necessary to employ the services of a work-over rig to repair mechanical difficulties which arose during the previous productive life of the well. It has been necessary to squeeze cement in order to shut off water leaks around the casing seat or to control bottom hole water after the productive section has been opened and produced. During such operation it is not uncommon to leave a cement sheath plastered over the fact of the pay zone. This condition either prevents entirely or cuts down materially the entrance of oil into the well. If the productive section is of considerable length the acid jet gun is generally used as it would be uneconomical to remove the cement sheath mechanically.

The acid jet gun connects to the bottom of the tubing, is lowered into the hole and spotted opposite the section to be jetted. Acid is then introduced into the tubing and impinged against the formation through jets in the gun, causing a high velocity stream of inhibited acid to dissolve and disintegrate the cement. The removal of scale which has accumulated during the productive life of a well on the bottom hole equipment, such as screens, liners and so forth, is easily and economically accomplished with the aid of the jet gun. The use of the jet gun reduces the volume of chemical solution required; therefore, the cost of reconditioning such a well is held to a minimum. The acid jet gun also has been employed advantageously where a well is producing from a thick section, generally limestone formation. In such cases, the amount of acid required to completely cover the exposed section would exceed the limits of economy. Therefore, through the use of a smaller amount of acid in conjunction with the jetting action obtained with the jet gun, the desired results are obtained at small expense to the operator.

Still another use for the jet gun is that of drilling out cement plugs with acid, as well as the deepening of wells completed in a limestone formation. For this type of work, a special drilling head is used on the bottom of the jet gun. The acid is then jetted against the cement plug or lime formation, and the desired results are obtained through a combination of the jetting action of the acid, together with the solubility of the materials in contact with the acid.

This last mentioned adaptation of the acid jet gun led to the development of more proficient acid deepening equipment. In some fields it has been found that material increases in production were obtained by deepening the wells a short distance. Where this is the case various conventional drilling methods have been employed. However, the cost of moving in tools to drill and clean the wells is prohibitive in most instances. Through the use of acid deepening equipment, operators have been able to keep cleaning out and deepening costs at a minimum. The equipment used for deepening wells with chemicals has been simplified greatly so that no expensive or cumbersome equipment is necessary. A standard pulling unit, in most cases, is the only equipment furnished by the operators.

Acid deepening of wells is accomplished by circulating acid through specially designed jets installed in a standard rock-bit. The main advantages of acid deepening of wells lie in its economy, costing about 25 percent less than the standard drilling methods. Other advantages are: (1) Minimum amount of equipment required by operators; (2) bailing of the well and mud conditioning are not prerequisites to the acid drilling method; (3) shutdown time is held to a minimum, usually not over two days being required to deepen the wells; (4) no clean-out is necessary after deepening; (5) a small well crew consisting of one tubing unit operator and helper is all that is needed. A regular tubing crew will be needed to make the two round trips of the tubing at the start and finish of the operation; (6) the acid serves a dual purpose; it does most of the drilling and increases the permeability of the pay zone; (7) as most of this type of work is done in limestones, the cuttings are dissolved by the drilling fluid, eliminating use of a bailer for their removal.

With the accomplishment of better control of application of the chemicals, together with additional chemical compounds with which to work, the field of beneficial services in the reconditioning of wells steadily broadens. There are many fields in which numerous wells are penalized in production due to high gas-oil ratios. Toward this end the chemical engineer introduced a chemical compound called formation plug. The plug, in a liquid state, can be pumped into the well and displaced into the gas bearing part of the formation and there held in place until set. The formation plug is forced into the formation as a fluid containing no suspended particles and sets into an impermeable mass, thus effectively blocking the pores through which the gas has entered the well. The oil productive section of the exposed pay zone may be blocked off with jelly seal or by other means, prior to the application of the formation plug, and in this manner the engineer is assured that only the gas bearing strata will be plugged.

The use of the electric pilot, which has previously been discussed, has played an important part in the gas-oil ratio control work. With its aid the engineer has been able to apply acid selectively to the oil-bearing section of the exposed formation. In this manner he has accomplished increases in permeability throughout the oil producing zone, thus increasing the percentage of oil produced, and thereby effecting a lower gas-oil ratio. This particular style of treatment is especially advantageous from an economic standpoint in fields which enjoy lenient allowables and in the conservation of reservoir pressure.

The control of water-oil ratio is a problem of long standing to the oil producer as the entrance of water adds greatly to the operating cost, thereby severely damaging the operator's economic structure. Into this field chemistry has introduced the use of specially designed plastics. The use of plastics to shut off water has proved to be extremely economical and most effective, as it is inexpensively applied and is a permanent plugging agent. The plastic is applied in a fluid state, with

the aid of a specially designed bailer and sets to a hard resin in a few hours time. This plastic plug is impermeable and possesses abnormally high bonding strength with the formation. This high bonding strength together with assured penetration of the plastic into the formation, due to the absence of colloidal material in the fluid, are characteristics which have long been sought as an effective, economical means of absolute control of oil-water production problems. By the use of plastics in the East Texas field alone many wells have been converted from pumping to flowing wells by the complete elimination of water. Other wells which were producing an abnormally high percentage of water prior to the application of the plastic plug are now producing their allowables with only a very small percentage of water.

Chemistry as applied to production and reconditioning problems is firmly established and there can be no doubt of its present economic importance. The continued cooperation between petroleum and chemical engineers assures the constant flow of new chemicals, new and improved mechanical devices and more proficient techniques in their approach to petroleum problems. Therefore, as we view the future of chemistry, in this role, the benefits to be derived from its continued application in the petroleum industry assume infinite proportions.

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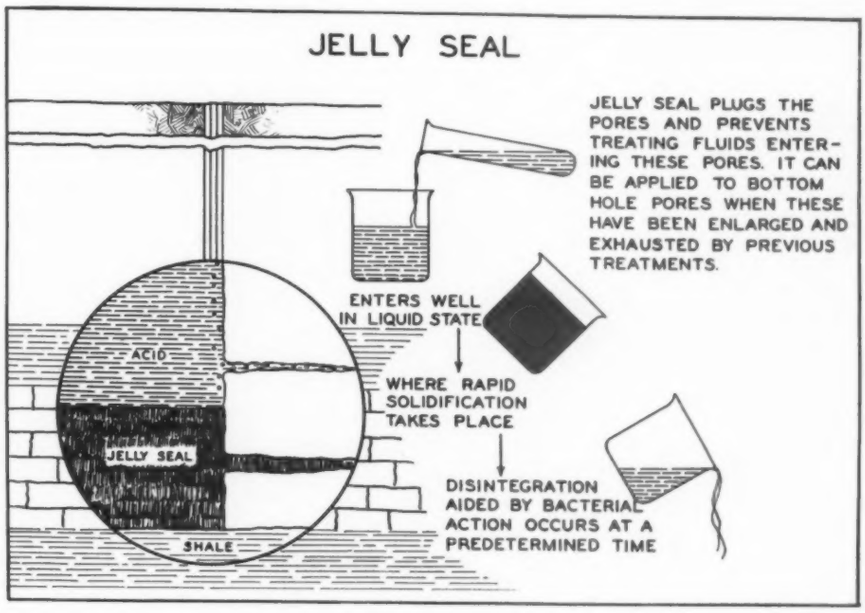
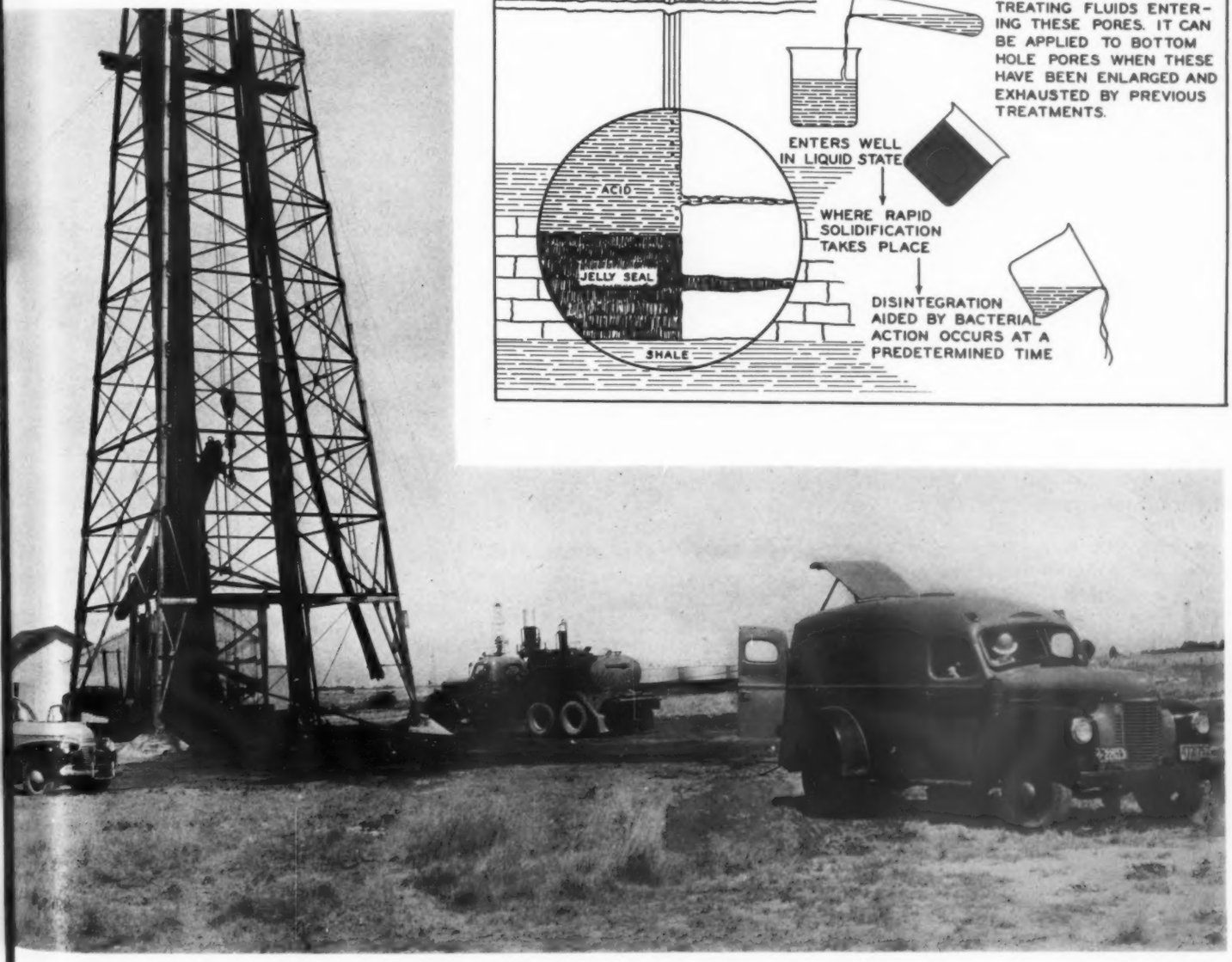
Left: Testing jet gun prior to running.

Below: Selective acidizing with the electric pilot.


JELLY SEAL
JELLY SEAL PLUGS THE PORES AND PREVENTS TREATING FLUIDS ENTERING THESE PORES. IT CAN BE APPLIED TO BOTTOM HOLE PORES WHEN THESE HAVE BEEN ENLARGED AND EXHAUSTED BY PREVIOUS TREATMENTS.
ENTERS WELL IN LIQUID STATE
ACID
WHERE RAPID SOLIDIFICATION TAKES PLACE
JELLY SEAL
DISINTEGRATION AIDED BY BACTERIAL ACTION OCCURS AT A PREDETERMINED TIME
SHALE



★ ★ ECHOES FROM THE WASHINGTON OIL FRONT ★ ★

By **W. J. Maddox,** Chief of Washington Bureau

Change in Middle East Mission

Abe Fortas

MYSTERY continues to envelop the plans and activities of Petroleum Reserves Corporation. A new crop of rumors was set in circulation a fortnight ago when Abe Fortas, former Undersecretary of the Interior, who had been designated as head of PRC's mission to study the Middle East oil situation, abruptly resigned and accepted induction into the Navy as an apprentice seaman.

There had been some Congressional criticism of the Fortas appointment on the ground that he had no familiarity with oil. The answer to this was that there were several experienced technical men on the mission and that the task of the chairman was to make diplomatic arrangements with officials of the country or countries where PRC might wish to operate. Fortas's explanation of his resignation was his impatience with the delay of the mission in getting under way although this was attributed in part to difficulties in arranging transportation.

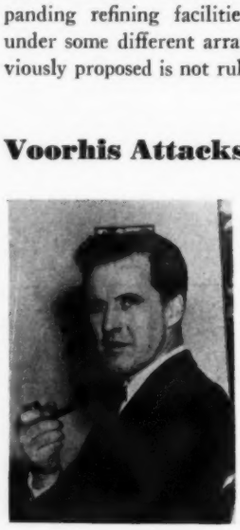
Following his announcement it was rumored that the projected expedition would be abandoned or indefinitely postponed but it is now understood that the mission will proceed as planned and probably will be on its way before this appears in print; further, that it will be headed by E. L. DeGolyer, well-known geologist and former Assistant Deputy Petroleum Administrator, who was the original choice for this position.

May Look for a New Deal

MEANWHILE it has been definitely published and not denied that the negotiations previously under way with the California Arabian Standard Oil Company by which the government, through PRC, sought to take over the company's concession in Saudi Arabia or to acquire a large stock interest in the company, have been discontinued. Unwillingness of the company to accept the proffered terms of the government is the commonly assigned reason. Meanwhile rumors have been in circulation that PRC may divert its attention to other areas in the Persian Gulf region, either to Kuwait where an oil field has been in course of development under joint ownership of Gulf Oil Corporation and Anglo-Iranian Oil Company, Ltd., or in the area between Kuwait and Saudi Arabia control of which has been in dispute between the two for years past.

A more probable theory is that the Middle East mission will make a report covering the general situation in that part of the world that will serve as a guide to such action as the government may decide to take. Meanwhile the possibility of expanding refining facilities in the Middle East under some different arrangement from that previously proposed is not ruled out.

Voorhis Attacks Directive 70



Rep. Voorhis

REPRESENTATIVE Jerry Voorhis of California, is concerned lest PAW's Directive 70 governing foreign oil operations, as well as other directives issued by PAW, is leading to "a more extreme monopoly situation in our oil industry than any we have ever known before."

Addressing the House recently, Voorhis declared that WPB's certificate that Directive 70 is necessary to the prosecution of the war goes much further than merely suspending the antitrust laws with regard to the decisions, program and actions of the foreign operations committee under the directive. "The certificate," he asserted, "is all that was needed to make complete suspension of the antitrust laws an accomplished fact. Such suspension has by that certificate been approved in blanket fashion by the chairman of the War Production Board and henceforth anything whatsoever which the foreign operations committee may decide to do now or in the future is exempt from any antitrust law on the statute books."

Fear International Rationing

SENATOR Truman's investigating committee also has picked up the scent of what they suspect is an international scheme for control of the world's oil supply. They attribute the idea to Petroleum Administrator Ickes and they are bent on knowing more about the government's oil policy and plans for participating in such an undertaking. The subject has been discussed for some time behind closed Congressional doors, and it is reported that the scheme for internationalizing petroleum has the cognizance of the President. The plan is understood to call for control of world petroleum reserves through a joint committee of the United Nations. The Petroleum Administrator for War is represented as global-minded and not averse to being given the job of heading up such a committee. Under the reported arrangement the committee would ration oil on an international basis.

Truman Pursues Canol Inquiry

IN turning the searchlight on the global oil activities of the administration, the committee first looked into the Army's $130,000,000 development in Northwestern Canada—commonly called the Canol project. First witness called was Petroleum Administrator Ickes who promptly touched off verbal fireworks by declaring that the enterprise was unsound, would be of no practical value after the war and should be junked to save the government the $30,000,000 still required for its completion. The Secretary declared that he never had been consulted regarding the undertaking and that the first information that came to him regarding it was through a chance conversation of Deputy Administrator Davies with one of the contractors engaged in the work. "The project never would have been undertaken", he asserted, "if we had had anything to say about it."

It would have been far cheaper, the Petroleum Administrator said, to transport oil by tanker from California to Skagway and pump it by pipe line from there to Whitehorse than to bring it across the mountains from Norman Wells. The same amount of oil that will be handled by the Canol pipe line, he declared, could have been moved by one good-sized tanker making four trips a year.

The War Department stands by its guns, however, and Undersecretary Patterson put in a vigorous defense of the Canol undertaking as a war emergency measure, declaring that it would be as sensible to criticize the cost of Salerno on the basis that the land captured was worth only a few dollars an acre.

Foreign Division Split in Three

W. D. Crampton

PAW's reorganization of its foreign division into three units with an over-all operating committee to co-ordinate their work is said to be due to the recent expansion in activities. It is just a normal growth, but as part of its added responsibilities the division is preparing to take up the duties that will be entailed in administering Directive 70.

William D. Crampton, formerly associate director of the foreign division, has been named director of foreign supply and distribution; William B. Heroy, formerly PAW's director of reserves, will be director of the foreign production division; and C. Stribling Snodgrass, former associate director of the foreign division will be director of the foreign refining division. A foreign operating committee, composed of the three chiefs with Crampton as chairman, will coordinate the work of the division. According to Deputy PAW Ralph Davies, the three divisions "will continue to function along the same lines they pursued when they were organized as sections in the foreign division. In recent months the work of each section has developed to the point where it was becoming unwieldy to operate as one division."

Action Sought on Oil Price Bill

Rep. Disney

At last it begins to look as though a crude-price-increase bill might get Congressional consideration. Proponents even predict that once such a measure is before the House they can muster enough votes for its passage. Oil members have had phenomenal success in getting signers to the "discharge" petition that would take the Disney bill to boost crude prices to parity from the Banking and Currency Committee, where it has been pigeonholed for months, and place it before the House. Now that the signatures of a majority of the House—218 members have been obtained the backers of the bill expect to bring it to the floor by Dec. 13, the first discharge date.

One reason for the progress made is that after months of shadow-boxing oil-state members have at long last got together in throwing their weight behind something tangible—in this instance the Disney bill. Some help has come too from the independent producers who have been dropping into Washington from time to time to see their Congressmen.

The stiffening attitude of both Republicans and Democrats against OPA and subsidies on both sides of Congress has boosted the crude-price cause. Economic Stabilizer Vinson's suggestion of a subsidy instead of a flat, over-all crude-price hike has furnished them something to shoot at.

The Disney bill, if and when it does come before the House, will probably face a stiff fight, maybe even a stiffer one in the Senate, if it gets that far. And if finally wrapped up and sent to the White House, it undoubtedly will draw a Presidential veto. The President would back up Vinson, whose decision to turn down Ickes' recommended increase, certainly reflected his own views.

Ickes Seeks Subsidy Formula

Meanwhile Secretary Ickes is going ahead with Judge Vinson's suggestion and searching for some plan or program for stimulating discovery of more crude reserves short of a general price increase. Judge Vinson expressed the opinion that he "entertains no doubt whatsoever of the ability of PAW, in cooperation with the Petroleum Industry War Council, to devise a practical, workable program for giving additional financial support to exploratory activity and development of new fields without increasing the cost of living, burdening government or business with an impossible administrative task, or dispensing public funds to those not engaged in exploratory activity or development of new fields."

However, thus far PAW has been unable to discover or invent any such plan. Ickes has set his staff to work on the problem, and at the API meeting in Chicago, called on the industry to "undertake immediately to try to formulate some program or policy, other than a general price increase—one which we can conscientiously recommend to Judge Vinson as practical, workable and administratively feasible."

He told the oil men that he was unwilling "in view of our needed additional reserves, to allow this question of proper financial incentives for producers to remain unsolved. Therefore, it is necessary that we proceed in good faith and with all possible speed. This, as I have said, is the next step. Only after we have attempted to devise such a program as has been requested can we in PAW determine what the steps thereafter shall be."

Ickes is going to try to find some formula, but he has his fingers crossed—and in the meantime is beating the bushes for another method of attack when he has to report failure.

New Chief of Army's Oil Supply

Brig. Gen. Peckham

Brig. Gen. Howard L. Peckham is the new chief of the Army's Fuels and Lubricants Division, which is responsible for all petroleum supplies, except aviation gasoline. He succeeds Brig. Gen. William E. R. Covell, who was placed in charge of the division when it was created last June by Lt. Gen. Somervell, chief of Army Service Forces.

Lt. Col. Jay L. Taylor, formerly vice president and general manager of Halliburton Oilwell Cementing Company, continues as second in command. General Peckham is an army man, but the division has drawn largely on the oil companies for the approximately 100 officers on its staff.

Production at Norman Wells

Just before the Truman committee began its hearings on the Canol project, information was released both in Washington and Ottawa, that 27 wells connected with the development are now producing. Wells drilled to July 1, 1943 were producing 3,000 b/d and more was in sight.

Twenty-six wells in the Norman field were completed by Imperial Oil, Ltd., under contract with the U. S. government, and 23 of these produced oil. Four wells were drilled outside of the field under the contract, at a distance from the area, and three on the edge of it. Prior to the agreement, four additional wells had been drilled, making a total of 27 that went into production. It was disclosed also that the pipeline from Norman wells to Whitehorse is scheduled for completion about January 1944, and the refinery at Whitehorse is to be in operation probably by May. The line from Skagway to Whitehorse was said to be in operation.

First Use of Gasoline from Coal

Rep. Randolph

Next move in enactment of legislation for government construction and operating of demonstration plants for making oil from coal is up to the House, where Rep. Jennings Randolph is to carry the ball. The O'Mahoney fuels-from-coal bill recently passed the Senate. Randolph's bill in the House is a companion measure. The bill passed the Senate with but slight discussion, and a similarly smooth course is expected in the House. Only objection to the proposal was that the government might go into competition with private business in the production of synthetic fuels. An amendment met this objection. Meanwhile Congressman Randolph has achieved the distinction of being the first statesman to make a trip in a plane powered by gasoline derived from coal. The trip extended from West Virginia to Washington and the gasoline was supplied by the pilot plant operated by the Bureau of Mines at Pittsburgh.

Record December Quotas

PAW Ickes has certified to the various oil producing states for December a record production rate of 4,694,200 b/d of all petroleum liquids. This is a net increase of 58,500 b/d over the November production certification. The rate for each district showed a net increase, except District 1 where a slight decrease was made to conform with the productive capacity of the oil fields in that area.

Foreign Oil Legion

Ralph T. Zook

RALPH T. ZOOK, newly elected president of the Independent Petroleum Association of America, has long been identified with association activities in the industry. His first contact with the oil business was as a sales engineer for gas engines and gasoline plants from 1909 to 1914. In the latter year he formed a partnership with Wm. J. Sloan out of which grew the Sloan and Zook Company of which he is president. The activities of the combination were first concerned with the manufacture of liquid hydrocarbons from natural gas. Later it extended to secondary recovery operations in New York and Pennsylvania and subsequently included production and refining. He is a former president of the Pennsylvania Grade Crude Oil Association, a director of the Bradford District Oil Producers Association, a director of the National Stripper Well Association and a member of the Petroleum Industry War Council.

J. E. BRANTLY, president of Drilling and Exploration Company, is spending several weeks in Brazil where his company is conducting exploratory drilling for the National Petroleum Council representing the Brazilian government.

ANSON G. PHELPS, traffic manager of Standard Oil Company of New Jersey, is retiring under the company's annuity plan after 42 years of service. Edward D. Sheffe, assistant traffic manager, moves up to take Mr. Phelps' place. Mr. Phelps has spent his entire career with the company. He became manager of the Traffic Department in 1933. Three years later he was made chairman of the company's newly created Transportation Committee which was formed to coordinate rail, barge and pipe line movements.

Mr. Sheffe joined the Standard organization in 1912. He has handled most of the company's cases before the Interstate Commerce Commission and is also a registered practitioner before the United States Maritime Commission.

THE War Department, Army Map Service, Corps of Engineers, U. S. Army, is seeking maps, city plans, port plans, place name lexicons, gazeteers, guide books, geographical journals and geological bulletins, covering all foreign areas, outside the continental limits of the United States and Canada. They are particularly interested in maps and guide books purchased within the last ten years. Those who are not prepared to donate such material to the War Department, may lend it for the duration, or long enough for reproductions to be made. Franked labels will be forwarded for their convenience. Maps issued by the United States Government and the National Geographical Society are not wanted. Persons who have maps available are asked to write to Miss Viohla Klipell, Head of N. Y. Library Branch, Army Map Service, Room 820, 1270 Sixth Avenue, New York, 20, N. Y.

ELMER R. SMITH, export engineering representative of Lane-Wells Company has completed an extended trip through South American oil fields. His trip covered Peru, Venezuela, Columbia, Trinidad and Mexico, and revealed a keen interest in the possibilities of increased production in all these countries.

Margaret Corrie

FIRST woman to occupy a key executive position in Union Oil Company's organization, and one of the first to serve as director of public relations for a major oil company, is Miss Margaret Corrie whose appointment to this position was announced by President Reese Taylor on November 1. Miss Corrie has been connected with Union Oil for the past five years except for an interim when she was located in Washington as administrative assistant to the chief of the Iron and Steel Branch of the War Production Board.

SENOR LUCIANO RESTREPO, who has been actively identified with oil development in Colombia for the past thirty years, and who was recognized as the foremost figure in the country's industry, passed away early last month at his residence in New York. Senor Restrepo was instrumental in enabling Roberto De Mares to prove the De Mares concession which subsequently was taken over by International Petroleum Co., Ltd. Later he joined with John W. Leonard in organizing the Leonard Development Company which drilled a number of wells on the Las Monas structure, and in recent years he had participated in the development of several other concessions besides organizing the royalty company "Regalias Petroliferas Colombianas S. A."

Educated at Stevens Institute of Technology and Columbia University, Senor Restrepo had a multitude of friends in the oil industry, both in his native country and in the United States. When the news of his death was announced to the Colombian Congress, both Houses adopted motions of condolence addressed to his family.

J. E. Brantly

Elmer R. Smith

Luciano Restrepo

Don't get left

Refiners who put off their post-war planning too long are likely to be left at the post—or at least, not to be in at the finish

CATALYTIC CRACKING	HYDROFORMING
REFORMING	DEHYDROGENATION
HYDROGENATION	POLYMERIZATION
ALKYLATION	UNISOL TREATING
ISOMERIZATION	RETREATING
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SWEETENING

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WPB APPEALS TO OIL INDUSTRY FOR MORE SCRAP

INFORMATION collected by the Industrial Salvage Branch of the Salvage Division of the War Production Board shows that the nation's stockpile of scrap steel is falling to dangerously low dimensions. At last report, inventories of scrap, iron and steel had fallen to a 37 day supply. Some of this inventory does not lend itself to peak steel production. And this is at a time when the expanded scale of war operations calls for a great increase in steel manufacture for use in merchant ships and naval craft, in tanks, combat vehicles, guns, and for general munitions production.

The vital importance of an adequate supply of scrap to the maintenance of the war production program is well understood by most readers of WORLD PETROLEUM. It is exemplified by the simple fact that half of every ingot ton of steel is made from scrap. This means that many tons of scrap are required for every ship, tank and gun or other war machine that is wholly or mainly of steel construction. Nothing else can more quickly or more seriously hamper the war effort than failure to maintain a constant supply of scrap metal.

In the earlier drive for the accumulation of metal scrap a relatively large amount was collected from individual families, from attics and basements, farm yards and rubbish heaps but this is a non-recurring supply. Once it has been gathered up no more can be obtained from the same source, at least not for the duration of the war. The most dependable sources of supply and the ones that yield large tonnages of the kind of steel most readily useable are the industrial plants of the country. And in the yield of such material the oil industry ranks very near the top.

For this reason and because of the urgent need for substantial tonnages of metal to replenish dangerously dwindling supplies a special appeal is being directed to the management of oil enterprises to resurvey their shops, refineries, storage yards and other establishments for discarded or obsolete materials and equipment that can be diverted to the national service without serious loss or injury to company operations. Every branch of the industry must contribute substantial tonnages of scrap if the urgent needs of war production are to be met.

Top ranking officers of the oil companies alone have the authority needed to make decisions affecting disposal of much needed heavy scrap. Special emphasis is being placed on dormant scrap. Idle machinery, equipment and materials make ideal No. 1 heavy melting scrap. All industry is today engaged in efforts to salvage dormant scrap.

Dormant scrap is defined as machinery, equipment, tools, dies, moulds, fixtures, etc., which are obsolete or which are incapable of current or future use in war production because they are broken, worn out, irreparable, dismantled, or in need of unavailable parts. Dormant scrap should not be construed to apply to reusable machinery and equipment which can currently or in the future be used by the owner or others, with or without repairs, to contribute directly to war production.

If continued peak steel production is to be maintained throughout the coming months, the petroleum industry must increase the tempo of its salvage efforts. In order to reach the over-all industry goal of 9,800,000 tons of iron and steel scrap before the year end, each oil company must step up its salvage efforts in line with the efforts of all industry.

Salvage managers and their committees should do these things as soon as possible:
(1) Resurvey all plants and properties as sources for dormant scrap.
(2) Prepare an up-to-date list of all idle and obsolete equipment, machinery and tools.
(3) Arrange to dispose of all items they know to be unquestionable as scrap.
(4) Arrange to study questionable items for future disposition.

Operations of the general salvage branch of the War Production Board are being carried on through more than a million volunteer workers on a country-wide basis. The country is becoming decidedly scrap-conscious. This points the direction for some very effective public relations advertising. The petroleum industry is urged to tell the story of their scrap program work in trade and consumer media. Such publicity is very desirable for its effect in keeping the scrap program before the trade and public audiences. Salvage and scrap work must be on a continuing basis for the duration of the war.

Another critical shortage has developed in waste paper, more critical than at any time since the war began. This has come about through the drop in wood pulp production, the raw material of brown paper and paperboard. The wood pulp shortage comes from the steady decline in wood cutters, who cut pulp wood for the paper mills. And the only substitute for the wood pulp raw material is properly processed waste paper.

Some mills have already drastically curtailed operations because of lack of waste paper. Others are working on waste paper inventories of days or even hours.

It may not be generally realized how important this waste paper is to the war effort. Paper has gone to war. It is used in a wide variety of war and munitions equipment.

Enormous amounts of brown paper and paperboard are used in making shipping containers for offshore delivery of food and munitions. The petroleum industry is urged to salvage as much of this material as possible. All waste paper is urgently needed. As evidence of this, an understanding has been reached whereby waste paper consumers have agreed to buy at ceiling prices, all grades of waste paper, properly processed, until February 15, 1944. This agreement should provide a powerful stimulus to industry in the collection of all grades of waste paper. All kinds of paper are needed including paper from office and order department files, shipping containers, brown paper and paperboard.

This Standard Refinery Yielded 3,500 Tons of Scrap

Fig. 1—Floor view of Stedman pilot plant, showing still, part of column, control board and receiving tanks.

100 PLATE PILOT FRACTIONATING UNIT

By L. B. Bragg and J. W. Lewis, Jr.*

THE major objective of all industrial processes is normally directed toward a maximum return on investment. Each process must stand on its own two feet financially or be sentenced to economic oblivion. Industrial competition and profit incentive demand that the desired results be effected at minimum cost. The process engineer must determine the optimum operating conditions which will produce the greatest enonomy and his efforts are greatly facilitated if adequate process data from pilot plant operation are available.

Some correlation is possible between laboratory tests and the operating characteristics of commercial size units, but as a dependable medium by which optimum operating conditions can be set and yields predicted with reliable accuracy, the value of a pilot plant is unquestioned.

Efficiency of fractionation is one of the most important factors having significant influence on the overall economics. When the fractionator preceding a chemical process produces a charge not meeting the specifications for the most economic operation, chemical consumption increases and yields of valuable products decrease. Such a condition is not necessarily a reflection on the ability of the fractionator to produce the desired quality. Fractionation involves many variables and it may be that because of the absence of pilot plant data, the process engineer cannot readily determine the optimum operating conditions. If he finds it necessary to depend on whatever laboratory information may be available, his own experience and experiments, he must then wait, and hope that a desirable balance will result. During this time, a unit of large capacity may lose enough valuable product to pay for the cost of a pilot plant. Just such an undesirable condition is also possible where fractionation is used to separate finished products, particularly where the specifications, physical and chemical, approach those of a pure compound, or, as in some petroleum fractions, where there is a large difference in octane rating for a small difference in boiling point. In these and similar cases, economic balances may be seriously affected.

An adequate and flexible pilot plant serves to clarify many operating problems and it would seem that attempting to control large industrial units without benefit of pilot plant experience is attended with much speculation. Realizing the very definite need for pilot plant data in design-

* Engineering Department, Foster-Wheeler Corporation.

ing industrial processes employing fractionation, Foster Wheeler has installed in its laboratory at Carteret, N. J., a pilot plant fractionating unit using Stedman packing, having the following features:

(1) A 6-inch fractionating column, containing 16 feet of Stedman packing, having a separation capacity equivalent to approximately 100 theoretical plates.
(2) A batch charging capacity of 160 gallons, making larger distillate fractions possible for complete analysis.
(3) Automatic control of the heat input to the still to maintain a constant pressure differential across the column, permitting maximum throughput rate.
(4) Automatic top-of-column temperature control.
(5) Wide range of operating pressure (high vacuum to 300 pounds per square inch).
(6) Electrically heated column jacket permitting adiabatic column operation.
(7) Still heating by electricity, steam or Dowtherm vapor—the use of the two latter in conjunction permitting accurate control of the temperature of the heating medium.
(8) Semi-or full continuous operation.
(9) An overall height from floor line of less than 28 feet. Fig. II shows a simplified flow diagram of this unit.

Perhaps the shortest cut to an understanding of what Stedman Packing is and how it works can best be made through an understanding of its basic feature: the provision of entirely independent paths for the flow of the liquid and of the vapor.

When a wire screen of proper mesh is adequately wetted with a liquid, a liquid film forms over the open spaces of the screen and over the wire from which the screen is made. This film forms on both sides of the screen.

If such a wetted screen surface be slightly inclined and more liquid be fed to the screen at the higher level, an even flow of liquid over the screen surface (top and bottom) results. If a great number of such screen surfaces be arranged in exact geometric pattern, (See Fig. III) so as to produce a great surface of flowing liquid, with a systematic arrangement of vapor passageways which produce a positive vapor flow over and around that surface, a veritable honeycomb of descending reflux surface is achieved with which the ascending vapor makes a great number of contacts per unit height of packing.

The separating efficiency of Stedman packing is well established. Its ability to separate individual hydrocarbons (and other compounds) of 99 per-cent plus purity has been demonstrated, not only in the laboratories of Foster Wheeler but also in

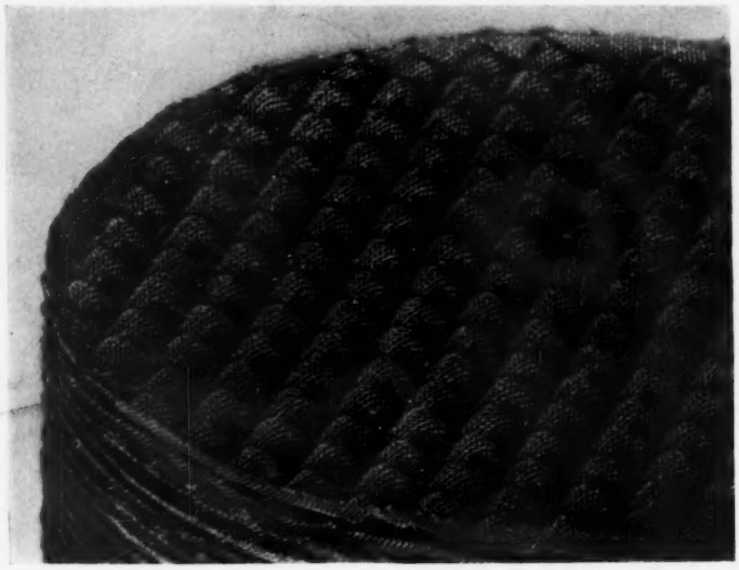
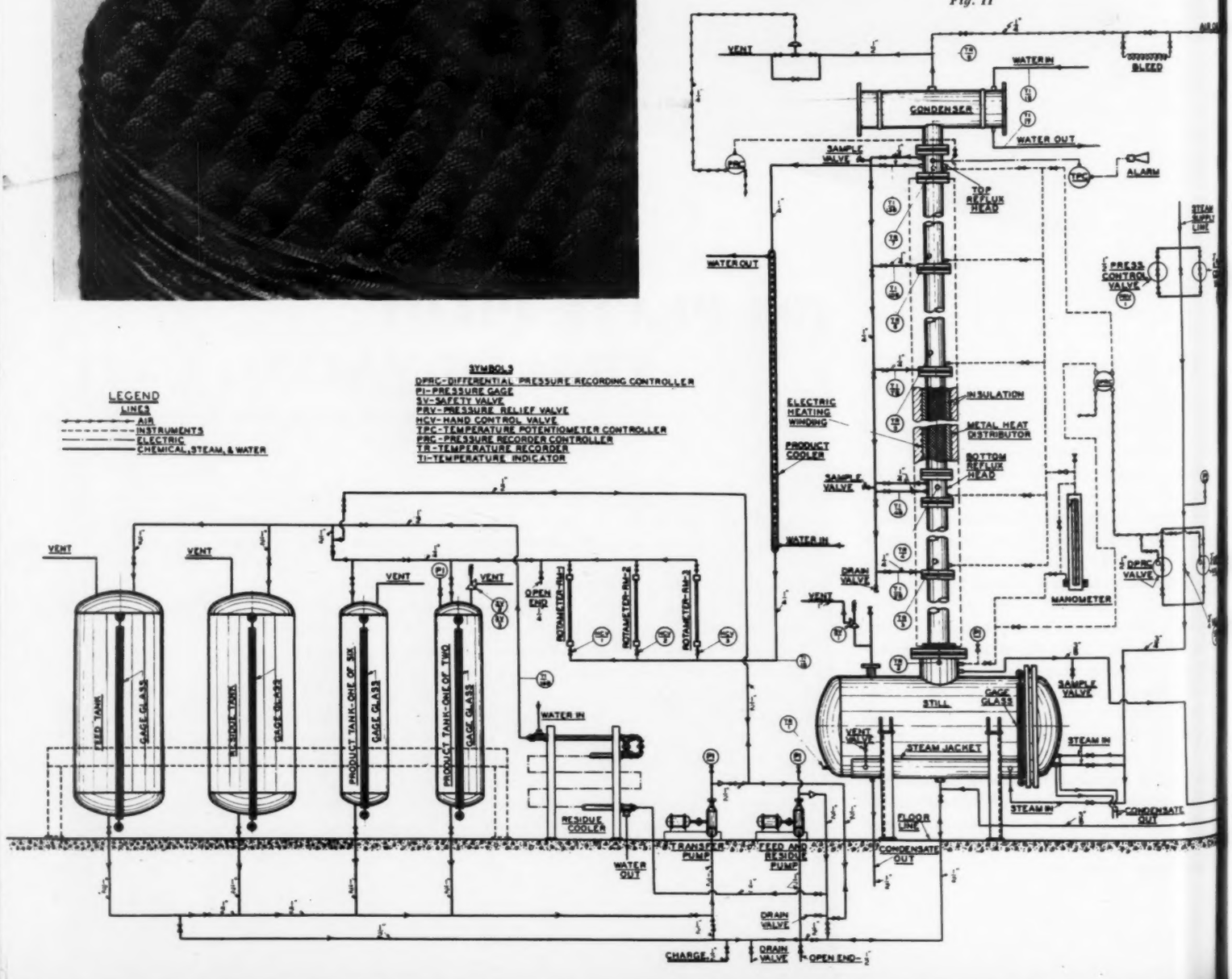


Fig. III—Left; Section of packing illustrating pattern of pyramids, vapor openings, valleys and side slip.

Fig. II



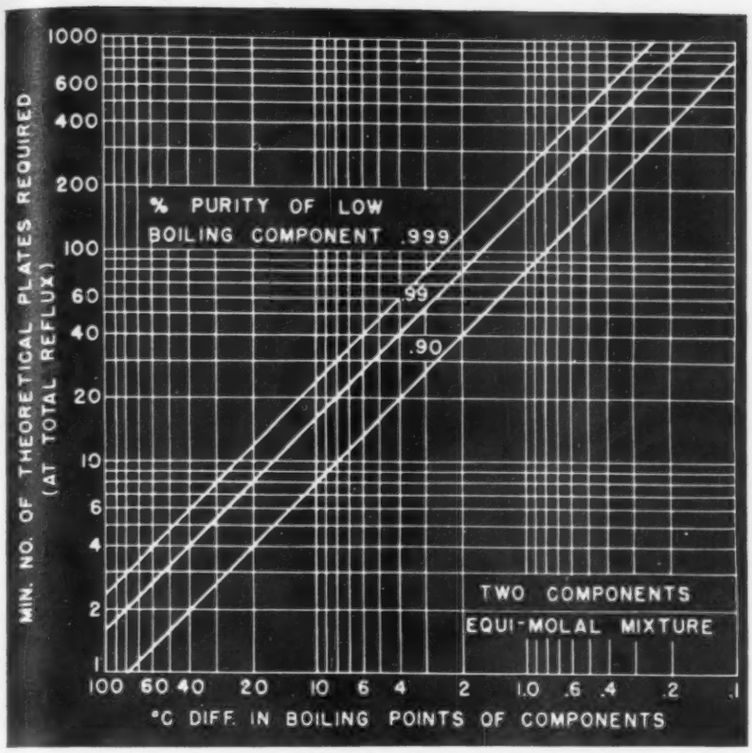


Fig. IV

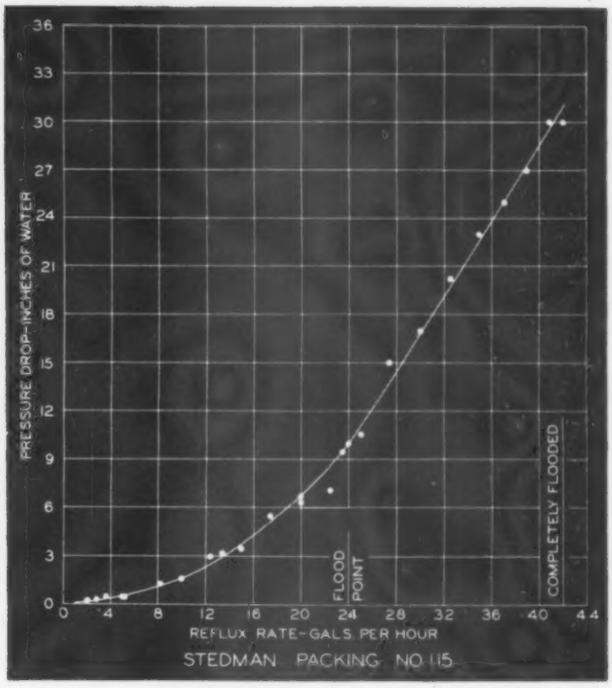


Fig. V

the laboratories of many of the leading chemical and oil companies and in the research bureaus of the government.

The column in the unit here described contains 16 feet of Stedman packing. Under the usual operating conditions this column will contain about 100 theoretical plates and for convenience sake the column is given a 100 plate rating, at which condition the H.E.T.P. (Height Equivalent to a Theoretical Plate) is 1.92 in. A column of 100 plates is adequate for most fractionating problems facing the distillation technologist today, and is in fact more than sufficient for many separations.

A quick approximation of the minimum number of theoretical plates required to effect different degrees of separation from different types of charges may be obtained from the data shown graphically in Fig. IV.

This graph shows the relationship between (a) the degree of purity required in the fractionation of the more volatile component of an equimolal mixture of two components, (b) the minimum number of theoretical plates required, and (c) the difference in boiling points of the two components of the charge.

For example: (a) the boiling point difference between Butane and Iso-Butane is 9.44°C., to produce an Iso-Butane of 99.9% purity from an equimolal mixture of these two hydrocarbons would require a minimum of 27 theoretical plates; (b) the boiling point difference between Octane and Iso-Octane is 26°C. and from an equimolal mixture of these two hydrocarbons, an Iso-Octane of 99.9% purity may be separated with a minimum of 10 theoretical plates; (c) 100 theoretical plates, using total reflux, will separate a 99.9% pure product out of an equimolal mixture of two components having a boiling point difference of 2.4°C.; a 99% purity from a mixture of 1.6°C. difference and a 90% purity from a mixture of 0.8°C. difference. The graph also indicates that, for any given difference in boiling point, the required number of theoretical plates is roughly doubled when one moves from 90 to 99% purity.

In the research and development work on Stedman packing, operating pressures indicated that the differential between the top and bottom of the column could be utilized to control the permissible throughput rate to the column. This was subsequently found to be so and, inasmuch as throughput rate is a function of heat application, these three operating factors were combined into a simple but effective automatic control in which a predetermined pressure differential actuates the control valve which supplies the heat to the still.

The relationship of these operating characteristics is shown graphically in Fig. V.

The Foster Wheeler Corporation has developed the use of an improved Top-of-column temperature control mechanism. It has greater sensitivity and accuracy and insures maximum yield of desired product with a minimum expenditure of heat while at the same time increasing the sharpness of separation between fractions. In conjunction with the use of this mechanism, it is also frequently the practice to control Top-of-column pressure to avoid errors that would otherwise result from varying atmospheric pressure. One of the unique features of the improved temperature control device is a Klaxon warning given to the operator when the temperature increases above the control temperature, indicating that the column has reached its capacity to separate that product quality which corresponds to a specific temperature level or range.

Semi- or full continuous operation is possible. Connections are made at different points on the column for feed entrance.

Three major purposes were kept in mind in designing this pilot-plant unit:

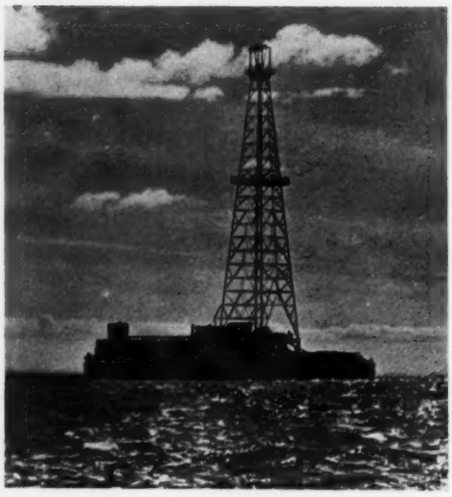
(1) To provide the engineering department with adequate and accurate pilot plant data on the fractionating problem of the moment.
(2) To provide operators of fractionating units with precise fractionation data on their charging stocks so that they may more accurately determine the optimum operating conditions to obtain the maximum economy.
(3) To disclose, in clearer perspective, the process obsolescence of existing plant distillation equipment and the economic justification for the construction of plant-size precise fractionation units.
(4) To create interest in and promote research in precise fractionation using Stedman packing.

Footnote to Fig. IV: This graph was developed from data shown in the article "Hydrocarbons in Petroleum" by Frederick Rossini (Table II), Petroleum Engineer, February 1943.

DEEP TEST DRILLING ON PRINCE EDWARD ISLAND

In the Gulf of St. Lawrence, near Charlottetown, Prince Edward Island, the Cities Service Company and Socony-Vacuum Oil Company, Inc. have undertaken jointly to drill a deep test well in an effort to locate new oil reserves in eastern Canada. Following a survey made several years ago, Cities Service Company acquired through a subsidiary the oil rights to the whole of Prince Edward Island, an area of about 2,184 square miles. During the summer months of 1940 and 1941 geophysical investigations were carried forward, and in 1942 Socony-Vacuum Oil Company, Inc. was invited to join in the investigations, and later decided to participate in the venture on a fifty-fifty basis.

Drilling is now under way eight miles south of Charlottetown in Hillsborough Bay where seismographic surveys indicated the crest of the anticline. It was necessary to erect a drilling "island" or foundation in open water having a depth of 16 feet at lowest tide and 26 feet at high tide where wave, tide and ice problems must be met. The foundation is of log crib construction, filled with some 8,000 tons of rock and concrete, and has a surface area of 9,000 square feet. It was erected by the Foundation Maritime, Ltd. of Montreal.



Exploration Well in the Gulf of St. Lawrence.

The drilling rig is the heaviest and most modern type available to suit conditions existing in the bay, and equipment is at hand to go to a depth of over 10,000 feet if necessary. All preparations are complete to continue drilling through the severe winter months, when transportation to and from the drilling site must be by motor sled over the ice.

Operations are under the supervision of The Island Development Company, a Socony-Vacuum subsidiary; and Loffland Bros. Company of Tulsa, Oklahoma, are the drilling contractors.

For many years past there has been a small production of oil and gas in New Brunswick province which is a next door neighbor of Prince Edward Island. Development of the industry on a substantial scale would be of value in supplying the requirements of eastern Canada, which must otherwise come from Latin-American countries or the Gulf Coast of the United States. It would also provide additional reserves to offset the dwindling volume of new oil discoveries within the Western Hemisphere.

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing with Technical and Economic Aspects of the Petroleum Industry—Edited by Dr. O. W. Willcox.

GEOLOGY

Discovery Thinking—A. I. Levorsen, in BULLETIN AMERICAN ASSOCIATION PETROLEUM GEOLOGISTS, Vol. 27 (1943) No. 7, pp. 887-928.

The question of enlarged petroleum reserves has lately assumed large importance, and brings to the forefront the problem of expanding the rate of new discovery. This author, who has previously emphasized the necessity of developing the geologic approach to the problem here makes an extensive restatement of this method of approach.

The basis of the recommended approach lies in the existence of wedge belts of porosity. A typical wedge belt is the woodbine sand which lies under the great East Texas oilfield. The characteristic of this sand is that it was tilted, its upper edge eroded and then covered by sediments which enclosed it under an impermeable layer, making it an ideal porous, updip stratigraphic trap for catching and holding the world's greatest petroleum deposit.

The application of the principle of wedge belts is simple. Once clearly understood, the concept of the undiscovered petroleum reserves of the United States can be expanded almost without limit. This is because there are thousands of miles of buried, updip, wedge belts of porosity in rocks which are known to produce oil and gas elsewhere, but are to-day only partly explored or completely unexplored. A wedge belt may be called the clue to a province whereas a local fold is the clue to a pool.

The author conceives that more than 10,000 miles of such wedge belts remain to be explored. Fundamentally, they represent the same type of geology which has in the past produced half a billion barrels of oil in the dolomite wedge belt of the Trenton formation of Indiana and Ohio; the same kind of geology which has and will produce 4 billion or more barrels of oil in the 60-mile porosity wedge known as the East Texas field; or which has produced more than a billion barrels of oil along the wedge known as the Midway-Sunset district of California. The evidence for these unexplored wedges is almost entirely in the geologic literature and they are each well known to most geologists. In some places the evidence is largely the result of surface mapping, in others it is the result of a few test wells, and in still others it is the result of various combinations of well known surface and subsurface data. If the confidential data in the hands of the oil companies were available, it is probable that as many more miles of unexplored wedge belts of porosity would be known as are known to-day. If to that is added the new wedge belts of porosity which will most certainly be discovered in the exploration of those wedges now known, the ultimate number of miles which remain to be explored should be sufficient to satisfy the most pessimistic of geologists for many years.

A second principle of geology which has a wide application to petroleum geology is the concept of successive layers of geology in the earth, each separated by an unconformity. They are present in most of the sedimentary regions of the United States and will probably be found to prevail the world over. The discovery of these layers of geology is generally the result of drilling, and many discoveries of oil have been contemporaneous with discoveries of totally unsuspected geology as well.

In the author's opinion the petroleum industry "is by-passing an important discovery tool" by failing to make an intensive use of geology and geologists for exploring the great possibilities that lie in wedge belts of porosity and layers of geology. His proposal is to return to geology as such, but on a much higher scientific level than heretofore. As a discovery tool, there is enough geology now rusting away in the sheds of our filing cabinets and in the background of our thinking to cultivate a really substantial and continuous crop of new oil fields. We have, in the form of more geological observation, more geological reasoning, and more geological understanding, discovery tools that will take hold as our present methods let go, and they are fully able to carry, not only the geologist but the oil industry itself, to new levels of achievement.

OPERATION

Flowing Versus Pumping Operations in Water Flooding—T. F. Lawry (Forest Producing Company), before AMERICAN PETROLEUM INSTITUTE, MID-CONTINENT DIVISION OF PRODUCTION, Tulsa, May, 1943.

Secondary recovery of oil from an oil sand by means of an artificial water-drive is effected by either the flowing or the pumping method. The flowing method is here defined as "that act of oil production whereby the oil and water produced from the oil well are brought to the surface by the carry-through of pressure in the sand, this pressure being supplied by the injection water. Fluid is permitted to accumulate in the oil well and in the sand until the pressure of the water traveling through the sand is sufficient to lift the fluid in the bore of the oil well". That is to say, the oil flows out at the casinghead under the pressure of the injection water. In general, the flowing method is as follows: The water-intake wells are drilled six to nine months ahead of the oil wells. During that time the injected water is filling the void areas in the sand, recompressing the free gas and driving some of it back into solution, until finally 100 per cent liquid saturation of the whole oil sand has been attained. This point of complete saturation is easily recognized from the intake records, which show that the sand is refusing to take any more water. When this point has been reached, the operator starts drilling his oil wells on the 5-spot

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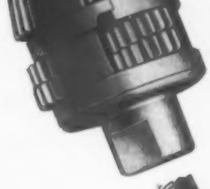

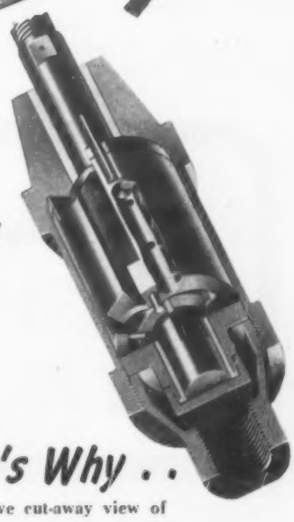

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plan, and brings them into production with due regard to the fact that they are under a pressure which will deliver the oil into the lease tanks.

In contrast with this flowing method, in the pumping method the water-intake wells and the oil wells are drilled at the same time; when everything is ready the injection water forces the oil to the bottom of the oil wells, from whence it is lifted to the surface by means of a pump in each oil well.

An apparent advantage of the flowing method is that the oil is lifted by pressure applied by the pump which also supplies water to the intake wells; the disadvantage of the pumping method is that besides the installation for forcing water into the sand, it is necessary to equip each oil well with an oil pump that is costly to install and expensive to operate, both as to materials and labor.

On the other hand, it is urged that the pumping method recovers more oil than the flowing method. All the arguments over the flowing method revolve about this point: whether it is cheaper to risk not getting as much oil by flowing, or to do the job the expensive way and hope to get more oil than would be obtained by pumping. The author, who is engineer of the major water-flood project in the Mid-Continent where both methods have been followed, states that it has been found that as much oil is obtained by flowing as by pumping. When Forests Flood No. 1 was converted from pumping to flowing, an unexpected advantage was found in an upward displacement of the decline curve, followed by a more gradual flattening of the curve than is obtained by pumping.

The technique that is best adaptable to flowing projects is that of limited withdrawal, similar to that used in flush fields under proration, where the day's production is taken in a few hours or minutes and the well is then shut in for the rest of the 24 hours. This allows a desirable back pressure to build up, and all wells are at peak production at one time, so that danger from water by-passing the oil is substantially lowered.

PHYSICS

Elasticity of Reservoir Rocks and Fluids—David Donoghue, before AMERICAN INSTITUTE MINING METALLURGICAL ENGINEERS, PETROLEUM SECTION, Dallas, May, 1943.

From studies on the East Texas oil field the author states conclusions suggesting that the concept of "water drive" might well be reexamined to include the expansion phenomena that occur when a water-driven oil horizon is being produced. The idea is that water is somewhat compressible, so that as a result of hydraulic pressure the water in the down-dip portion of a sand has a smaller volume than the water in the upper portion. When some of the weight is taken off the hydraulic column by withdrawal of oil and water from the wells the remaining water expands. The data indicate that in the Woodbine sand west of the East Texas field, one acre-foot of the "effective" sand expels 0.57 bbl. of water as a result of this expansion. At the same time, as the water is withdrawn the porosity decreases; that is, the sand settles; the pores become smaller and the sand becomes more compact. As a result of this compaction an additional 0.9 bbl. of water is expelled, making a total of 1.47 bbl. of water that moves into the oil-bearing zone from each acre foot of the water saturated zone for every 100 pounds decrease of pressure per square inch.

The pressure decline as of January, 1943, in the western part of the East Texas field has been approximately 550 lb./in. and the pressure gradient decreases westerly from the field until at some distance the pressure has not been affected by production of oil and gas in the East Texas field. The average pressure decline of 275 lb. over such area would yield 770,000 bbl. of water per square mile by compaction of the sand and expansion of the water.

If these assumptions and approximations are fairly accurate, it would appear that an area extending 30 miles more or less out into the basin north, west, and south from the field would yield sufficient water from the Woodbine formation alone to replace wholly or in large part the 1,850,000,000 bbl. of oil and the gas and the water produced to the end of the year 1942. It should also be apparent that in the East Texas oil field, oil and gas production, reservoir pressure decline, expansion of the gas, oil, and water and compaction of the rocks are complementary phenomena and that "water drive," whatever it may be, needs a redefinition.

Study of Reservoir Fluids by Surface Recombination Experiments—H. S. Batset and M. Muskat, before AMERICAN INSTITUTE MINING METALLURGICAL ENGINEERS, PETROLEUM SECTION, Dallas, May, 1943.

In recent years there has been greater recognition of importance of P-V-T data, which may be obtained in either of two ways: by bottom-hole sample analysis or by recombination of fluids as produced at the surface. The authors describe an

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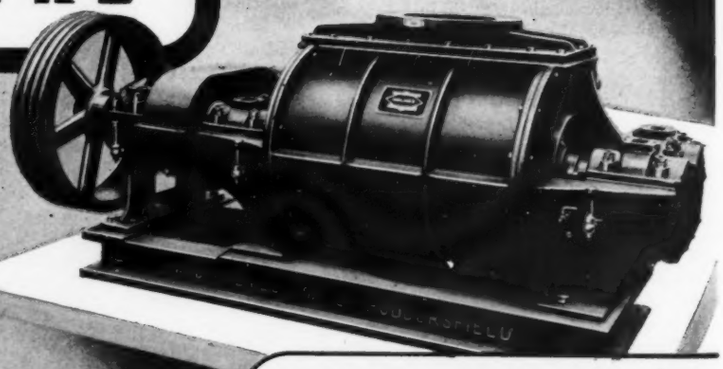

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apparatus for such recombination experiments which gives an accuracy of 1 or 2 percent or better, depending on the number of measurements.

The recombination experiment is begun with oil containing all its dissolved gas at room temperature. The separator gas is added and the bomb brought to reservoir conditions. After equilibrium is attained, the gas is bled off at constant reservoir temperature. As the gas solubility will be lower and vapor pressure of the residual oil will be higher at the reservoir temperature the oil sample in the bomb may give off more gas and vapor than the volume of input gas, even though the differential liberation process itself tends to yield less gas than flash liberation. It is clear that the closer the reservoir temperature is to room temperature, the more closely the relative volumes as obtained by flash recombination and differential liberation will approach their proper theoretical relationships.

A knowledge of the volume occupied by oil and gas in the reservoir under various conditions has a number of applications in connection with problems of production and in estimating reserves. The term "formation volume" means the volume occupied by unit volume of stock-tank oil (60° F. and 14.7 lb. per sq. in.) and the corresponding amount of gas for a given gas-oil ratio, at the reservoir or any other specified temperature and pressure.

The procedure for determining formation volumes with this apparatus is quite simple. The proper amounts of oil and gas to give a desired gas-oil ratio are introduced into the bomb. The bomb is placed in the constant temperature bath and the pressure is increased. Equilibrium may be reached at any desired pressure. The formation volume of the oil and gas is directly obtained. Usually a series of temperatures is chosen, at each of which the formation volume will be determined for a series of pressures, both ascending and descending. These may be made on the same sample for a fixed gas-oil ratio. After measurements have been completed at the appropriate number of temperatures, a new sample with a different gas-oil ratio is taken and the measurements are repeated. The data thus obtained are tabulated.

Furfural Solution Temperatures of Hydrocarbons. I. Evaluation of Mixed Aniline Point Determination and Application of Furfural—Harry T. Rice and Eugene Lieber, before AMERICAN CHEMICAL SOCIETY, Pittsburgh meeting, September, 1943.

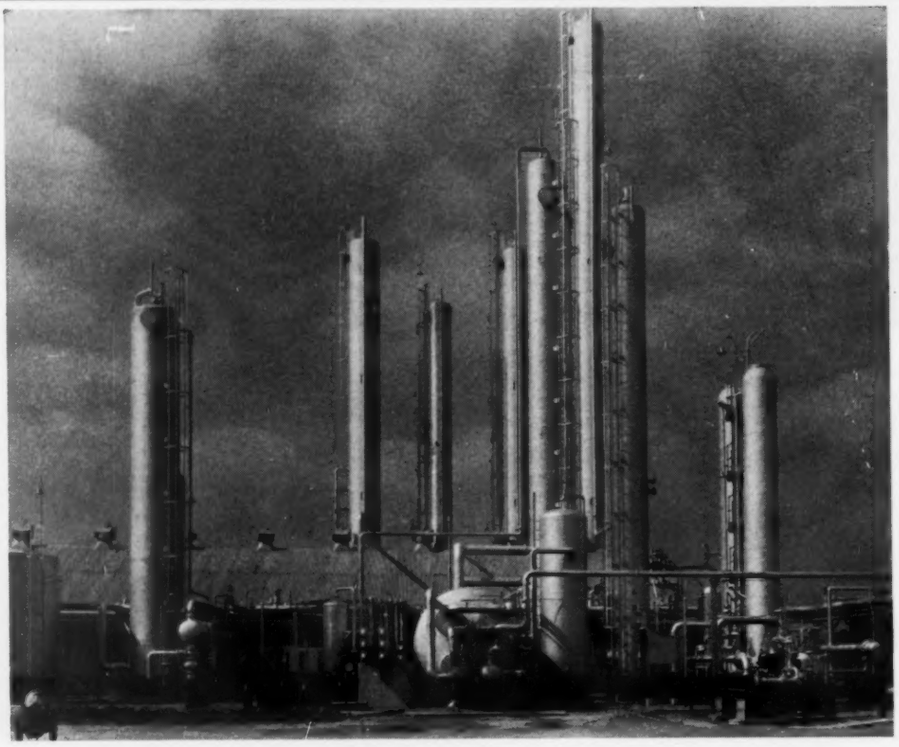
The solvency characteristics of various petroleum fractions of the type of solvent oil, solvent naphtha, Diesel fuels, various gas oils, etc., constitute an important index as to the properties such products will display in use. The determination of these characteristics has been an important task of the petroleum technologists, and various methods have been devised for their evaluation. Of these methods, those based upon the miscibility solution temperature of the oil and a solvent liquid are among the most important.

Of the various types of solvents proposed for this determination, aniline appears to have been accepted as the standard. This material has several defects which make it desirable to find a more widely acceptable substitute. For one thing, it is an extremely toxic blood poison.

Its chief disadvantage, however, arises from the fact that it cannot be used for the determination of the miscibility solution temperature of highly aromatic petroleum fractions because of its relatively high freezing point.

In an effort to circumvent this shortcoming, the so-called "mixed aniline point" has been introduced for evaluating these materials. This test is unstandardized and is completely meaningless as it is now used. The need for it can be eliminated by replacing the aniline with a solvent of lower melting point.

The application of furfural for the determination of miscibility solution temperatures of petroleum fractions has been studied. It appears to offer considerable promise over aniline. It is nontoxic and is applicable to a wide range of petroleum fractions. The point of complete miscibility is easily and readily determinable even in darkly colored fractions. It further shows considerable promise as a reagent to eliminate the "mixed aniline point" determination.



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(*Continued from page* 33)

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Wilshire Oil Company, Inc.	Norwalk, California

100 OCTANE PLANTS TO BE COMPLETED IN 1944

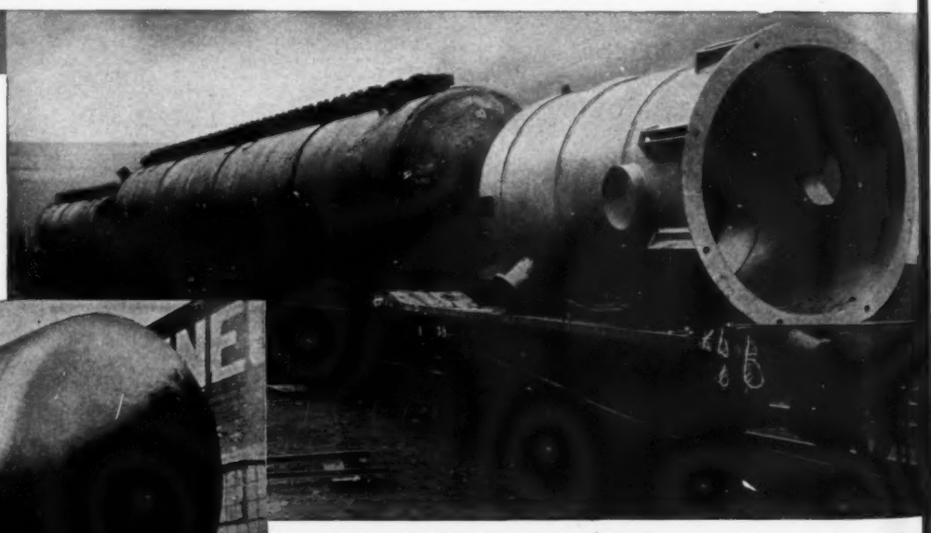
J. S. Abercrombie-Harrison Oil Company	Sweeny, Texas
Asiatic Petroleum Corporation	Curacao
General Petroleum Corp. of California	Torrance, California
Humble Oil & Refining Company	Baytown, Texas
National Refining Company	Coffeyville, Kansas
Pan American Refining Corporation	Texas City, Texas
Phillips Petroleum Company (2)	Borger, Texas
Richfield Oil Company	Wilmington, California
Shell Oil Company, Inc.	Wilmington, California
Shell Oil Company, Inc.	Wood River, Illinois
Socony-Vacuum Oil Company, Inc.	Paulsboro, New Jersey
Standard Oil Company of California	Richmond, California
Standard Oil Company (Indiana)	Whiting, Indiana
Standard Oil Company (Indiana)	Wood River, Illinois
Standard Oil Company of Louisiana	Baton Rouge, Louisiana
Sun Oil Company	Marcus Hook, Pennsylvania
The Texas Company	Wilmington, California
Tide Water Associated Oil Co. (2)	Avon, California
Tide Water Associated Oil Co.	Bayonne, New Jersey
Union Oil Company of California	Wilmington, California

REFINING

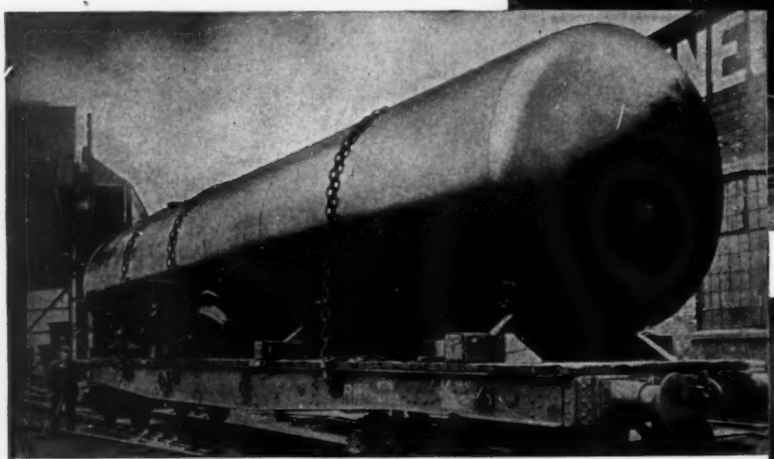
Improvement of Lubricating Oils from Comodoro Rividavia Crudes by Means of Solvent Treatment—Arturo Mennucci, Arturo Galbato, and Rudecindo Gatasa, in PROCEEDINGS 8TH AMERICAN SCIENTIFIC CONGRESS, VOL. 7, Phys. & Chem. Sciences, pp. 221-237.

In working out plans for the production of lubricating oils at the La Plata refinery (Argentina), a number of solvents were tried on light, medium and heavy distillates from Comodoro Rividavia crudes. These solvents included nitrobenzene, aniline, furfural, cresol, phenol, liquid sulphur dioxide and a mixture of liquid sulphur dioxide and benzene; liquid propane and the mixture of propane-cresylic acid (Duo-Sol process) were not tried, as these oils are practically free of asphaetic materials. In all cases the oils were finished by a treatment with one volume per cent of sulphuric acid, contacted with 2 per cent of superfiltrol clay and finally dewaxed. For medium oils, the solvents that show greater selectivity indicated by the values of the viscosity-gravity constant of the extract, were furfural and phenol. Cresol and the sulphur dioxide-benzene mixture were less selective. For the heavy oils, aniline and phenol show medium selectivity; cresol has a low yield and low selectivity. Furfural behaves with these heavy oils like it does with medium oils, as above stated; this solvent appears to bring about the polymerization of the fractions in solution, for which reason the extracts are of higher density, high viscosity and higher in carbon residue. It was not considered necessary to treat the lighter fractions.

WELDED PRESSURE VESSELS



5' 0" & 6' 6" DIA. × 90' 6" TOTAL HEIGHT. Lloyds Survey & A.S.M.E. Code.



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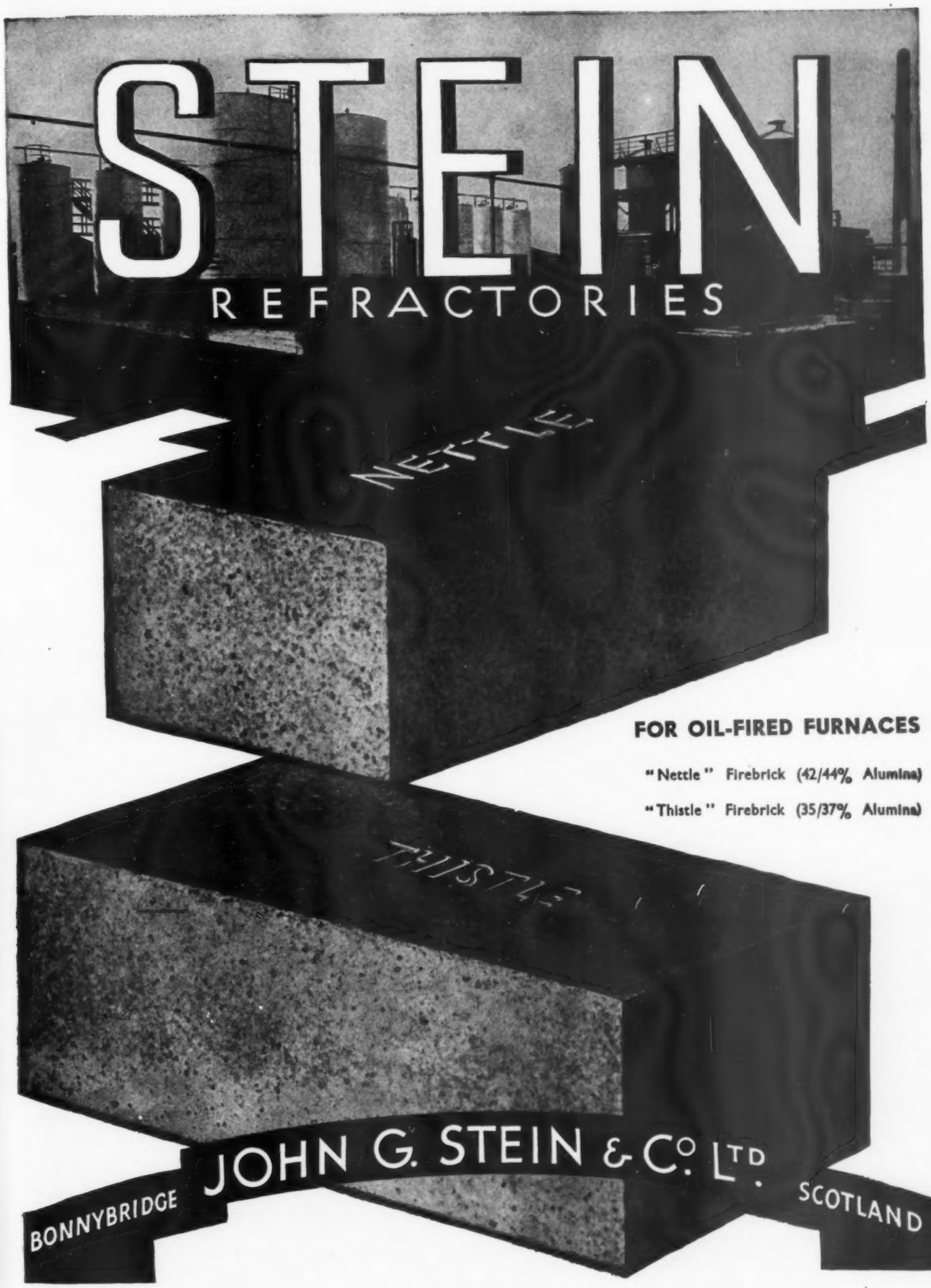
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The general properties of oils treated with nitrobenzene are satisfactory, although with the heavy oils there is a lower demulsibility, and the necessity of working at low temperatures is a disadvantage. Aniline produces good oils with somewhat lowered viscosities, but its easy emulsibility with water is an inconvenience. Of all the solvents cresol was the least promising—limited selectivity, low yield with heavy oils, which have high oxidation numbers. Sulphur dioxide offers no special advantage other than its low boiling point; the finished oils are good in general but have the lowest viscosity index; a further disadvantage is the elimination of the bloom which gives the oil a desirable appearance. The sulphur dioxide-benzene mixture is still more disadvantageous; the viscosity index is not improved, and the oxidation number is increased considerably.

This study pointed to furfural as the one that offered the greatest advantage of good selectivity, high yield in treated oil, low concentration of solvent in the treated oil, easy settling and centrifugation, and a lower toxicity to the refinery personnel. The finished oils present the best general properties: lower oxidation number, good viscosity index, and good demulsibility. Phenol is the next best.

The acid and clay treatment cannot be omitted; this treatment does not much affect the general characteristics, but notably improves color and appearance.

In the final dewaxing treatment the solvents that extract more wax from the finished oil are furfural, phenol, aniline and sulphur dioxide-benzene mixture; aniline dissolves more wax from the heavy than from the medium oils.

It is noted that the present study shows that the demulsifying properties of the solvent depend only on the treating procedure followed, and no relation can be established between interphase oil-water tension and demulsibility measured according to the method of A. M. S. T. P. 157.

Problems Involved in the Conventional Refining of Sour Crudes—R. B. Waite and R. H. Aitken, in OIL & GAS JOURNAL, Vol. 42 (1943) No. 13, pp. 27-32; 35; 53.

The growing demand for oil imposed by military necessity has forced some refineries to change from sweet to sour crude charge. Oil men who have had experience with sour crudes have lately published valuable information on the subject. The present article discusses experience in the refinery department of The Texas Company.

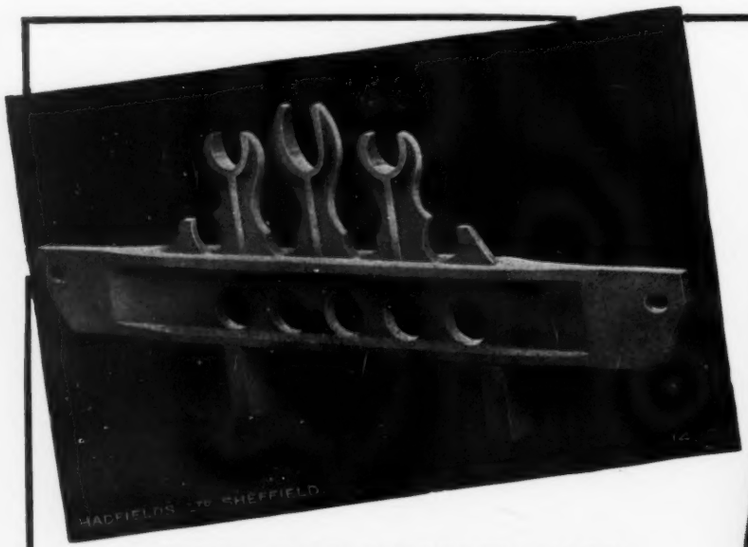
In the refinery mentioned a sour crude is processed to ultimate yields of gasolines and fuel oil. The crude is charged to the crude distillation unit at which an overhead cut of straight-run naphtha and a bottoms cut of reduced crude are produced. The raw straightrun naphtha cut is processed by passage through a catalytic clay desulfurization unit; desulfurized naphtha is caustic washed for H_2S removal and is run to tankage without further treatment.

In the catalytic clay desulfurizer most of the sulfur compounds are converted to H_2S and removed as gas; the rest is neutralized with caustic. The sulfur content is reduced from 0.13 to 0.025 per cent and the clear octaine raised 1.5 points CFRM, while TEL susceptibility is increased. This clay treatment gives considerable promise for the preparation of low sulfur aviation-gasoline stocks.

Raw naphtha produced by cracking the reduced crude is rendered substantially sulfur-free by stabilization, and for further sulfur reduction is given sulfuric acid, caustic and doctor treatments. The sludge produced in the acid treatment is burned.

The chief difficulties with sour crudes lie in the hazards to personnel and in the corrosion problems they present. The safety hazards are principally two: the toxicity of H_2S and the danger of spontaneous combustion of iron sulfide (FeS). H_2S is not only a highly poisonous gas but also forms an explosive mixture with about six parts of air, and the minimum safe concentration is not more than 0.02 per cent. Elaborate precautions are therefore required to protect men where H_2S gas is to be expected. The detailed directions given in this and similar papers should be observed. Great care should be exercised in opening tanks and lines that have contained products with high concentrations of H_2S on account of the spontaneous inflammability of the FeS that has formed on the walls.

Counter measures against corrosion include most of the expedients with which most refiners are familiar —selection of resistant materials, use of neutralizing agents such as anhydrous ammonia, caustic soda and soda ash, and acid resistant paints, though the suitability of the latter is questionable. Reinforced gunite has been used satisfactorily for the protection of tankage when the economics of particular cases warranted. Cement lined pipe has been satisfactory for field lines.



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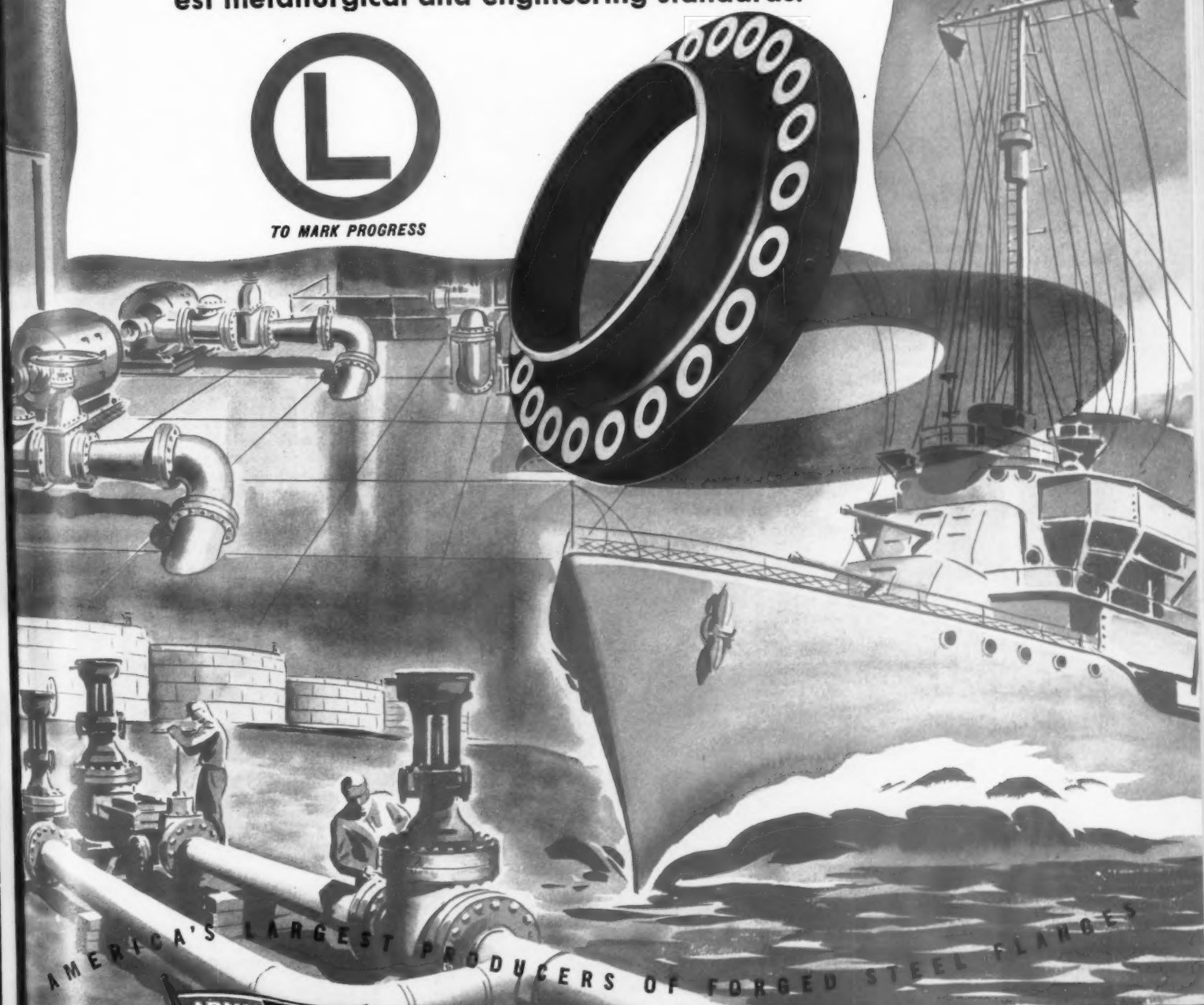

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GENERAL

The Fairbanks-Morse Diesel Engine as a Research Tool for Pre-Evaluation of Heavy Duty Motor Oils—H. L. Moir, W. J. Backoff and N. D. Williams, before Diesel Engine and Fuels and Lubricants Meeting, SOCIETY OF AUTOMOTIVE ENGINEERS, Cleveland, June, 1943.

These investigators were faced by a necessity for obtaining a background of actual temperature conditions accountable for lubricant decomposition on the hotter portions of the piston, particularly in the upper ring belt area where such decomposition caused ultimate engine failure by giving rise to piston ring sticking. Their choice settled on the Fairbanks-Morse Model 36A Diesel, which was fitted with a device for measuring piston temperatures. Experience showed that loss in power output was more sensitive to sluggish ring action or ring sticking than to increased piston temperature. Of the three types of oils tested—Pennsylvania 30, Mid-Continent 30 and Gulf Coast 30 (these are SAE numbers)—the Gulf Coast oils produced extremely dirty pistons, badly stuck rings and overall engine sludge, thus making cleanliness another factor to be considered in evaluating heavy duty type lubricants. The engine was accordingly modified by installation of automatic blow-by equipment and a crankcase sealing that successfully predicts both faulty ring action and ultimate stuck ring conditions. Further improvements allow of evaluating base oils containing additives. With this instrumental equipment it is now possible to evaluate piston cleanliness and ring sticking in a running time of 24 hours. An oil that will stand this test with a clean piston (rated on an arbitrary scale) with no stuck rings, will give a satisfactory 480-hour Caterpillar test and consequently saves much costly engine time.

Influence of Diesel Fuel Properties on Engine Deposits and Wear—G. H. Cloud and A. J. Blackwood, before Diesel Engine and Fuels and Lubricants Meeting, SOCIETY OF AUTOMOTIVE ENGINEERS, Cleveland, June, 1943.

Considering all phases of those studies, it is clear that the selection of suitable fuels is an important factor in the control of fouling and wear of automotive diesel engines. Assuming stability, freedom from water and soaps and absence of corrosive, abrasive and residual materials, the major diesel fuel characteristics governing automotive diesel engine fouling and wear are sulphur content, ignition quality and viscosity and/or volatility.

Of these properties sulphur content is the most important. Sulphur in diesel fuels is converted during combustion in the engine, chiefly to sulphur trioxide, which attacks the lubricating oil producing insoluble sludge that results in varnish and carbon formation and in increased ring and cylinder wear.

As regards ignition quality, the minimum cetane number acceptable will depend to a great extent on the sensitivity of the engine under consideration. The data indicate that little improvement in engine condition results when the cetane number is increased above that necessary for smooth operation. Reducing cetane number below this satisfactory minimum results in increased engine fouling. The effect of cetane number on engine wear appears to be negligible.

Fuel viscosity and volatility may show an appreciable effect on fouling and wear in certain types of diesel equipment. The very close relation between these two factors in normal fields makes it unnecessary to specify both rigidly. The limitations generally put on these characteristics for the control of smoke, etc., appear to be sufficient for the control of engine fouling and wear.

The influence of these fuel properties as determined in this work, particularly the influence of sulphur on fouling and wear, apparently cannot be applied directly to large slow speed diesels in Marine or industrial service. A 12-month test on two 13 x 18 diesel engines in Marine service—the starboard engine on one fuel and the port engine on the other—failed to show unusual fouling or wear on high sulphur fuel compared to low sulphur fuel.

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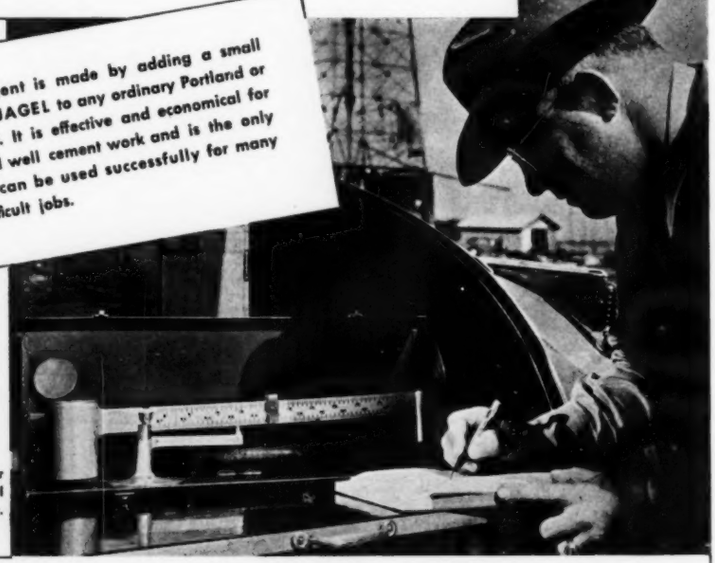

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Capital Flow and Capital Formation in the Petroleum Industry—Joseph E. Pogue and Frederick G. Coqueron, before PETROLEUM DIVISION AMERICAN INSTITUTE MINING METALLURGICAL ENGINEERS, New York, February, 1943.

This paper is a comprehensive survey of the operations of 30 American petroleum companies that in 1941 produced 52.5 percent of the domestic output of crude oil, ran to stills 79.9 percent of the nation's total crude oil processed, and in 1938 sold 85.1 percent of the gasoline consumed in the United States.

During the 8-year period covered by the survey, the capital expenditure of these 30 companies amounted to 5,275 million dollars. The report shows that the flow of this capital into the business increased when the price of oil rose and declined when the price of oil fell off, thus proving the thesis that it is price that regulates the flow of capital into industry.

As an average for the period, 60% of the funds in fixed capital assets went into the producing branch, while 40% was expended in all other branches. Over the eight year period, the total capital invested in leases, wells and equipment was 3,040 million dollars. During this same period, 9.5 billion barrels of crude oil were produced in the United States. If we assume that the 1941 ratio held for the entire period, then the 30 companies under consideration produced 52.5% of the total, or 5 billion barrels. If we assume further that 90% of the investment was allocated to domestic oil fields, then the average investment per barrel of production was 55 cents. In other words, during the eight years, 1934-1941, crude oil production in the United States increased 55% and for every barrel recovered 55 cents was invested in crude oil producing facilities. This relationship indicates the importance of reinvestment in maintaining crude oil supply.

The 30 oil companies reported net income for the eight years of 2,925 million dollars which, with the addition of 3,874 millions for capital extinguishments and 160 millions for other charges, indicates a total cash production of 6,959 million dollars, which was sufficient to support capital expenditures of 5,275 millions and dividends of 1,617 millions, with a margin left over of 67 millions. Dividends represented 55% of net income—a very conservative proportion—and only 23% of cash production. Therefore, out of every dollar of cash produced, 77 cents was ploughed back into the business.

It is shown that the average rate of return for the eight pre-war years was 6.4% with a range of 2.9% in 1934 to 10.1% in 1937. This 6.4% return on invested capital compares with a return of 8.7% for a group of 1,100 manufacturing companies.

The companies' net increase in debt is characterized as "very modest" and the existing ratio of debt to other forms of capital as "conservative." Investments in fixed capital assets increased in importance between 1934 and 1941, and rent assets became less important in relation to borrowed and invested capital. Nearly two-thirds of the capital invested went into the producing branch of the industry, indicating the high cost of replacing and increasing crude oil reserves.

The effiicency of capital utilization is indicated by the fact that the 30 oil companies under review increased their crude oil production 55% and their runs to stills by 52% as compared with a net expansion of 23% in gross fixed capital assets.

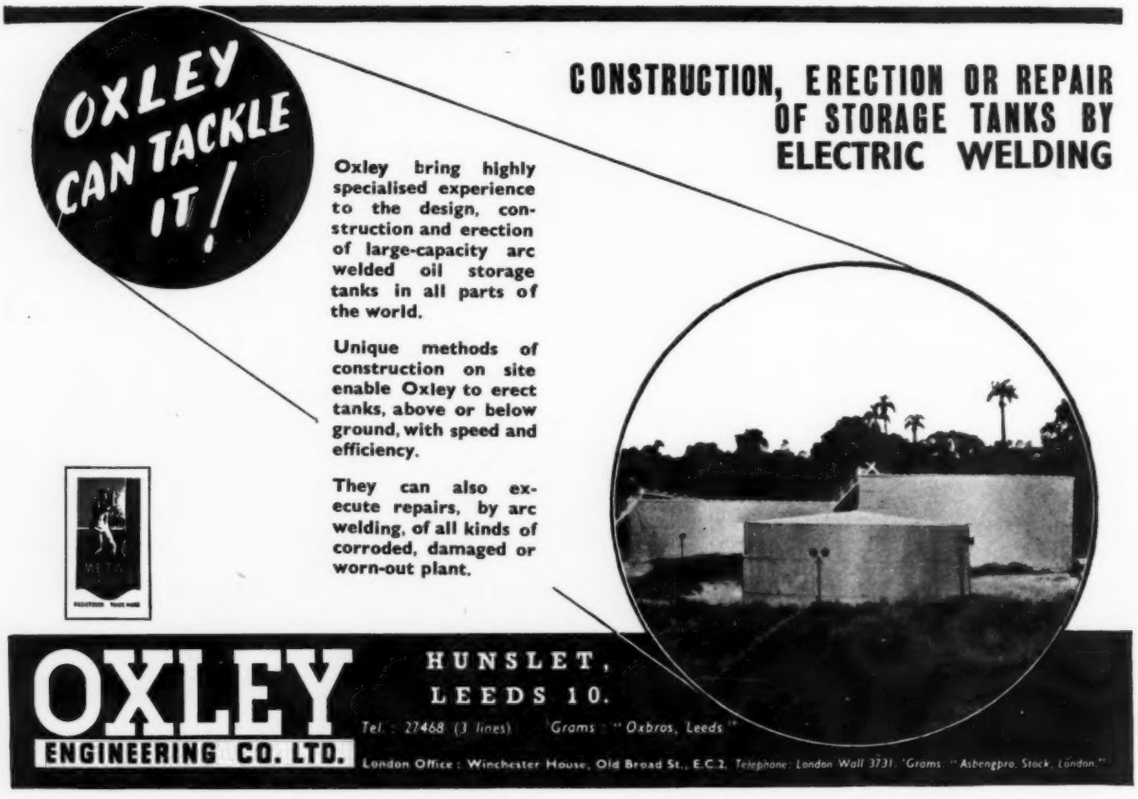
The gross investment in fixed capital assets on December 31, 1941, was 10.173 million dollars, divided as follows: production, 40%; transportation, 15.2%; refining, 18.7%; marketing, 15.1%; and all other, 2%.

War Developments in the Petroleum Industry—E. V. Murphree, in INDUSTRIAL AND ENGINEERING CHEMISTRY, Vol. 35 (1943), No. 6, pp. 623-631.

This paper discusses oil refining processes that represent new tools for the refiner that have been originated within the past few years, many of which are recent developments just beginning to be applied, and into which has gone an investment for new equipment of nearly a billion dollars.

One of these "new tools" which is employed as a preliminary step in the modern refining of crude oil is a refinement on the ancient art of distillation, and is called "superfractionation," by which complex mixtures of hydrocarbons are separated into extremely narrow-cut fractions. By this close fractionation the lighter and relatively more valuable constituents, particularly the iso or branched chains, are almost quantitatively separated as material for high-octane gasoline. With these segregated materials in his hand the refiner can proceed to apply the numerous new procedures, mostly catalytic, by which essential war materials are fabricated. The lighter isoparaffins, particularly isobutane, are now earmarked for alkylation with C_3, C_4, or C_5, olefins to produce alkylate as a blending agent for aviation gasoline. The process of alkylation is catalytic, with sulphuric acid or hydrofluoric acid functioning as the catalyst.

The supply of isoparaffins from natural sources being inadequate to meet the demand for alkylate blending agents, isomerization processes have come to the fore and are being employed especially for converting normal butane into isobutane; here aluminum chloride is used as the catalyst. This is a general reaction by which the straight molecules of such paraffins as hexane and heptane can be converted into branched molecules and the anti-knock qualities of these hydrocarbons is thereby greatly improved.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The war has given hexane and other higher normal paraffins another destiny, that of being converted into aromatics by a process known as hydroforming. In this process the straight paraffin and/or any 6-carbon-ring feed available (naphtha vapor) is mixed with hydrogen and passed through a bed of catalyst. Under the hydroforming process naphthenes give a higher yield or aromatics than the normal paraffins. This hydroforming operation is now used for obtaining synthetic toluene, and without it the country would be in a serious position in regard to a supply of TNT. A single hydroforming plant is making twice as much toluene as the whole coal tar industry. This process is also used for making high quality aviation gasoline.

The author reviews the three principle catalytic cracking processes—Houdry, Thermofor, and Fluid. Concerning the Fluid catalytic process it is noted that the principle of this process can be used in many processes for controlling the temperature in vapor or gaseous reactions, whether the circulating powder is a catalyst or not. The author also reviews the processes for making butadiene for synthetic alcohols and acids.

As stated at the beginning superfractionation is characteristic of war-time refining and is applied in all processes, whether crude distillation, alkylation, hydroforming, isomerization, etc., with the idea of obtaining well defined intermediate and final products. A conspectus of the fractionation of a crude oil in a war-time refinery is shown in the accompanying table.

PROCESSING OF CRUDE OIL

Fraction	% on Crude	Processes Used	End Use
Gas	0.7	Direct	Fuel
C_4	1.7	Fractionation, Isomerization, Alkylation	Aviation gasoline
		Dehydrogenation	Butadiene
C_5	2.6	Direct	Aviation gasoline
C_6	3.0	Fractionation	Aviation gasoline
C_7 (200° F.)	4.3	Isomerization	Aviation gasoline
200°-290° F.	11.2	Direct	Aviation gasoline
290°-350° F.	7.0	Hydroforming	Synthetic aromatics
		Severe thermal cracking	Butadiene
350° F., crude bottoms	57.5	Catalytic cracking	Aviation gasoline, Butadiene
		Severe thermal cracking	Isobutylene for Buty rubber

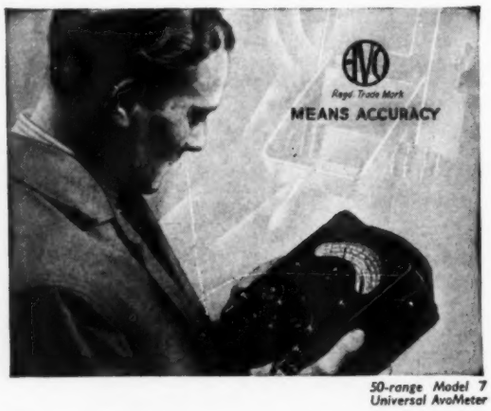
Less spectacular but highly important products of war-time oil refining are high quality lubricants for military engines, hydraulic oils for guns and cannon, asphalts that can be used to construct airports under wet conditions, rust preventives, synthetic alcohols and acids, and various new uses for petroleum as an offensive weapon on the fighting fronts.

Economic Results of Water Flooding—H. S. Milam, in OIL WEEKLY, Vol. 108 (1943), No. 10, pp. 15-16.

Spectacular results achieved in water flooding old oil properties in northeastern Oklahoma and southeastern Kansas in the not distant past have stimulated increased use of the method until at the present time approximately 40 percent of the daily oil production of this region is from properties under flood.

The cumulative total of oil produced from these properties by water-flood methods up to the first of this year has amounted to 15,525,098 bbl., with an average production of one bbl. of oil for each 11.4 bbl. of water injected. The best of these projects has produced an average of 6,550 bbl. per acre, and is still producing. In view of the indicated possibilities of further enlarging production, by means of water flooding, especially in view of the current alarm over the nation's producing capacity, it may seem surprising that at present the rate of development is beginning to decrease. This is not due to disappointing results, although there have been some disappointments, but is caused by water-flood economics. Water flooding has been conducted under narrow margins of profit, but now that wages and other operating expenses are increasing while the crude must be sold under a frozen price ceiling, there just is not sufficient margin remaining to provide an attractive financial inducement. Operators have a choice of either reducing development costs or the hopes of a higher crude-oil price, and until one or the other is achieved are not likely to expand their water operations materially. Consequently, the nation's producing ability is not being benefitted to the full extent that the region's possibilities offer.

Of course, there have been failures, most if not all of which can be ascribed to lack of careful planning based on thorough preliminary study. In many of these instances no cores were taken, or the cores and local geology have been inadequately inter-



50-range Model 7 Universal AvoMeter

THE Model 7 Universal AvoMeter is the world's most widely used combination electrical measuring instrument. It provides 50 ranges of readings and is guaranteed accurate to B.S. first grade limits on D.C. and A.C. from 25 to 100 cycles. It is self-contained, compact and portable, simple to operate and almost impossible to damage electrically. It is protected by an automatic cut-out against damage through severe overload, and is provided with automatic compensation for variations in ambient temperature.

The AvoMeter is one of a useful range of "Avo" electrical testing instruments which are maintaining on active service and in industry the "Avo" reputation for an unexcelled standard of accuracy and dependability—in fact, a standard by which other instruments are judged.

Some delay in delivery of Trade Orders is inevitable, but we shall continue to do our best to fulfil your requirements as promptly as possible.

Sole Proprietors and Manufacturers :—
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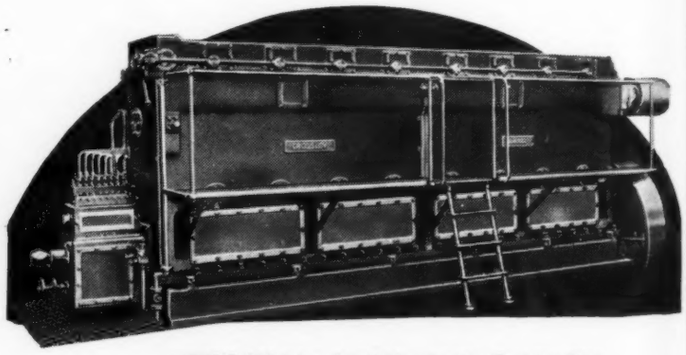
Winder House, Douglas Street, London, S.W.1, England. *Telephone : VICtoria 3404/7*



THE 800 b.h.p. 8 cylinder 4 cycle Crossley Diesengine illustrated, is designed for heavy duty, and o. medium weight and speed.

It represents the modern trend in Internal Combustion Engine practice, and is exceptionally accessible, although totally enclosed. Complete exposure of valve gear, etc., is obtained by sliding back the top aluminium covers, and adequate doors give access to crank chamber and cylinders.

Forced lubrication is employed, and starting is by compressed air instantaneously.

75 years experience as pioneers of the industry is a guarantee of efficient and economical operation.

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Vertical & Horizontal **DIESEL ENGINES**
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Built This Plant

Before erection began, Kellogg Engineers, skilled in basic chemical engineering processes and backed with years of work in practical research plus experience in converting laboratory and pilot plant experiments into commercial successes, had analyzed this particular refiner's problems.

The refiner assures himself of a successful plant by utilizing Kellogg's Integrated Service because all the varied functions of the engineer-contractor are concentrated within one organization.

DESIGN, CONSTRUCTION and LICENSING

CATALYTIC PROCESSES for Cracking, Hydroforming, Reforming, Dehydrogenation, Alkylation, Desulphurization
GASOLINE PRODUCTS COMPANY, INC....Pyrolytic Cracking • THE POLYMERIZATION PROCESS CORPORATION...Thermal and Catalytic Polymerization
JUIK Processes . . . for Lubricating Oil Refining with Propane and Phenol • Deasphalting • Dewaxing • Solvent Extraction and Acid Treating Plants

preted. In one case an attempt was made to flood the whole sand section where only the upper portion had payable oil; result, an immense volume of water was required. One project failed because the oil content was below average, of low gravity, and moved with great slowness. Low permeability, low gravity, and low saturation accounted for another failure. In another case a thick sand had a satisfactory total oil saturation, but the percentage of oil saturation was low, the percentage of water was high and the permeability small. The best that could be done was to produce 430 bbl. of oil per acre. All these mishaps, and others, might have been avoided if the operators had been well advised beforehand.

USES

Lubricating Oil Detergency—S. K. Talley and R. G. Larsen, in INDUSTRIAL ENGINEERING CHEMISTRY, ANALYTICAL EDITION, Vol. 15 (1943), No. 2, pp. 91-95.

Detergency is a necessary property of lubricating oils for use in internal combustion engines. Specifically, oils must have the capacity of carrying away soot and other combustion chamber detritus, as well as their own decomposition products, in order that engine deposits shall not accumulate and interfere with normal engine operation. This requirement creates a special problem in Diesels, which produce relatively large amounts of soot from incomplete combustion of the fuel, and it has been found necessary to incorporate detergent additives in oils for such service in order to avoid premature engine failure from ring sticking. High-output engines, which operate at high piston and cylinder wall temperatures, also create special detergency problems in regard to lacquering and ring sticking. For low-output engines, operating on clean burning fuels, the inherent detergency of plain mineral oil is usually sufficient to keep the engine clean.

While acceptable detergent additives have been on the market for a number of years, the development of newer and better additives has been hampered by the lack of simple laboratory methods of testing oils specifically for detergent properties. Engines have had to be used for this testing, even in the preliminary stages of testing experimental additives, although their use has simultaneously involved other variables, the least desirable of which has been a wide variation in quantity of material to be dispersed in supposedly comparable tests. Other reasons for desiring small-scale laboratory tests for detergency are small sample requirements, speed of testing, reproducibility, and at least a partial separation of variables. This paper describes four methods that have been found useful for investigating detergency on an empirical basis.

One is a chromatographic procedure for determining the depth of penetration through sand of lampblack suspended in the oil. Two other methods involve separation of asphaltenes from the oil, by centrifuging and by filtration through an asbestos mat, respectively. The fourth depends upon the relation between the degree of dispersion of oil-insoluble material and transmissivity to infrared radiation.

In the chromatographic test, lampblack was selected because of its similarity to the sooty fuel deposits in Diesel engines, and the laboratory results are in good agreement with experience on the Caterpillar Diesel. On the other hand, the procedures employing asphaltenes measure the peptization of oil oxidation products and correlate more nearly with ratings of the Lauson and certain other engine tests.

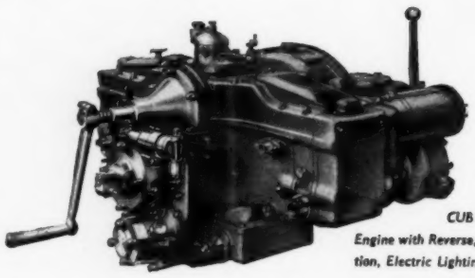
It is concluded that the laboratory tests are of interest in elucidating the nature of deposit formation in engines and, within limits, also provide a useful means for evaluating the detergent characteristics of lubricating oil additives. However, specific application of the tests requires consideration of the type of material deposited in a given engine as well as the operating temperature.

BOOK

Fuel Oil and Its Combustion—Issued 1943 by NORTH AMERICAN MANUFACTURING CO.: 37 pages; $1.50.

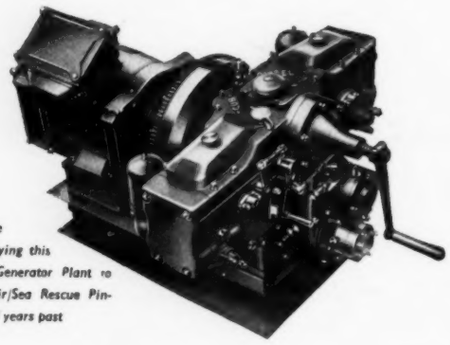
This is a book for users of fuel oil, who certainly constitute a numerous class, and are or should be much interested in the nature of the substance. The compilers of this booklet tells how crude petroleum is processed to obtain the various grades of petroleum fuel, from gas through to heavy oils. The technical terms employed in the fuel oil trade—distillate, residue (straight run and cracked), ash content, carbon residue, distillation test, flash and fire points, sulfur content, viscosity, and specific gravity—are explained for the layman. The layman is also instructed on the subject of heating values, how to interpret an analysis of fuel oil, and how to calculate the air requirements for combustion; what oils to select for particular purposes, and on various factors that are to be observed in the performance of a furnace.

MARINE · STATIONARY · VEHICLE



CUB 12 h.p. Marine Engine with Reverse, 2 to 1 Reduction, Electric Lighting and Starting

The World's Finest



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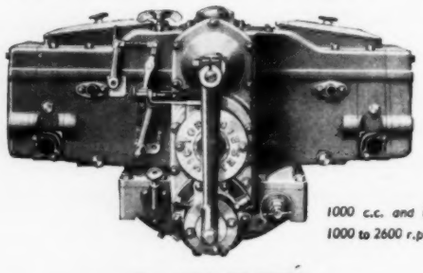

1000 c.c. and 1135 c.c. 2 cyls., 1000 to 2600 r.p.m., 300 lb. weight

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OIL ENGINES (COVENTRY) LIMITED

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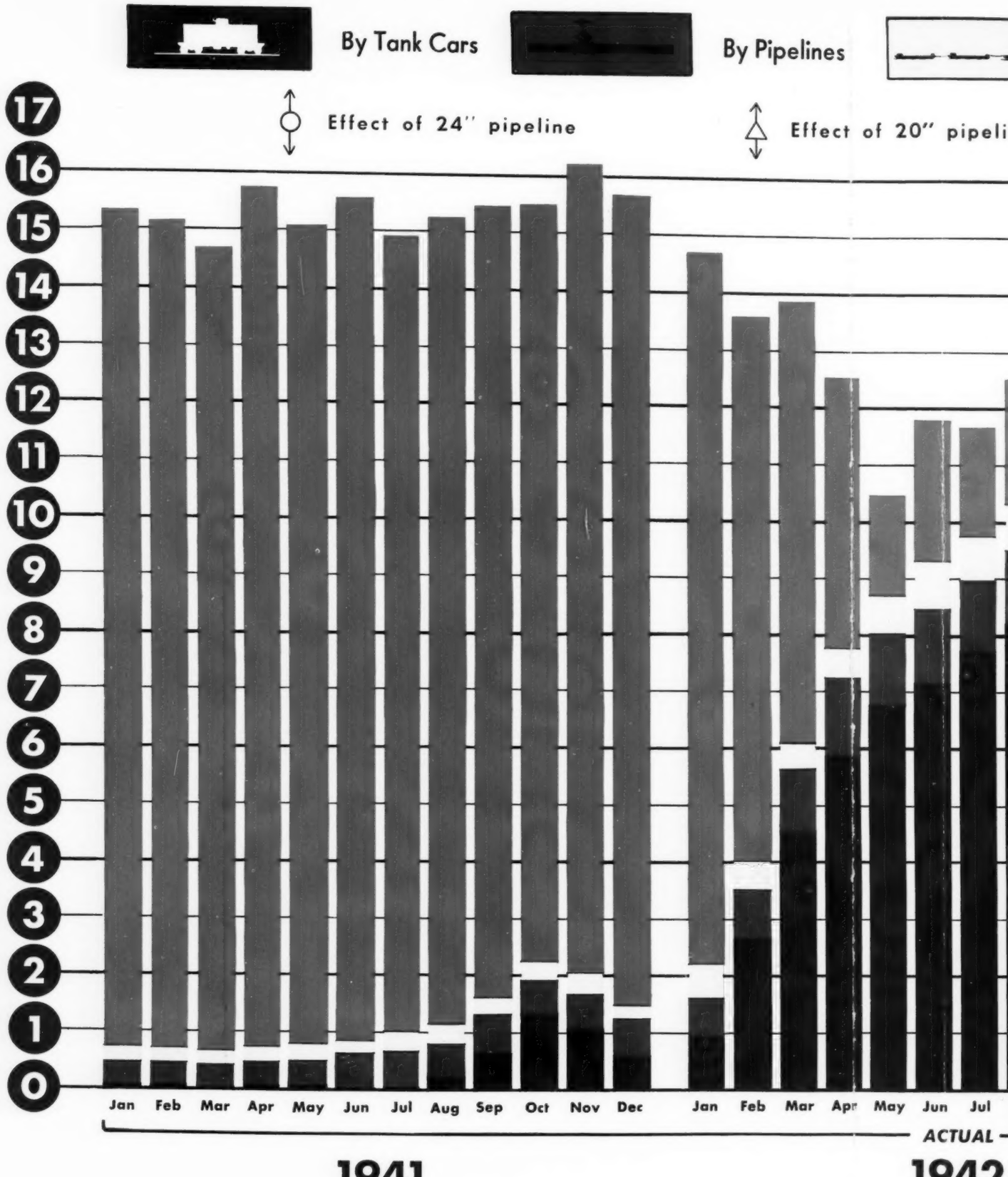
DELIVERIES OF PETROLEUM



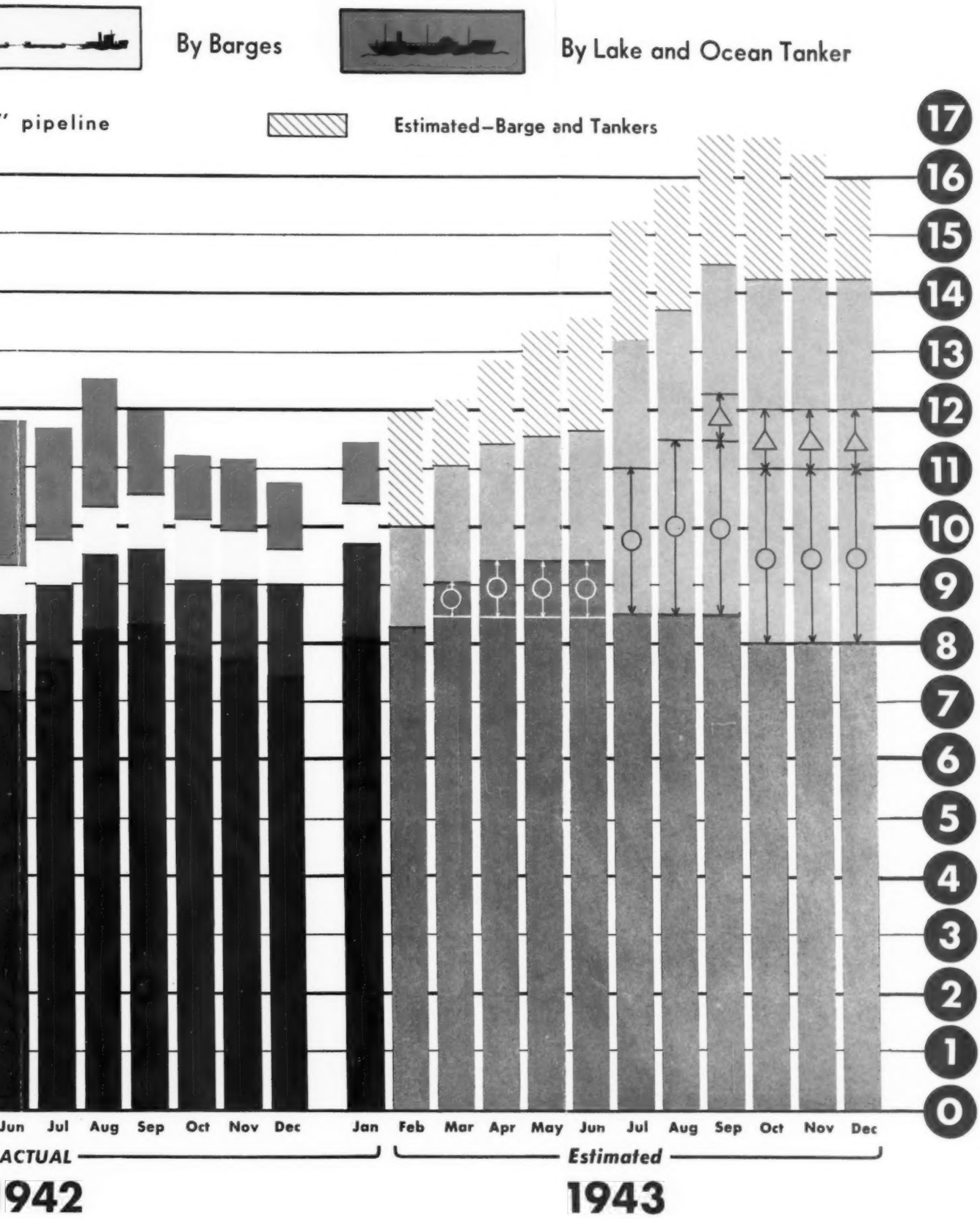
NOTE: Deliveries to District No. 1 (the 17 Atlantic Seaboard States) in 1941 were, in general, representative of pre-emergency conditions. Deliveries in 1942 show the transition from use of tankers to substitute means of transportation.

Estimated increased deliveries in 1943 reflect the effect of completion of the 24" line to Philadel section of the 20" line from the Gul

These estimated increased de greatly expanded military demand markets on rationed bases.

Supplement to WORLD PETROLEUM, Issue of April, 1943.

UM INTO DISTRICT No. 1



o Philadelphia and New York and the first
n the Gulf to Seymour, Indiana.

reased deliveries will be required to meet a
demand for petroleum and to supply civilian
s.

1943.

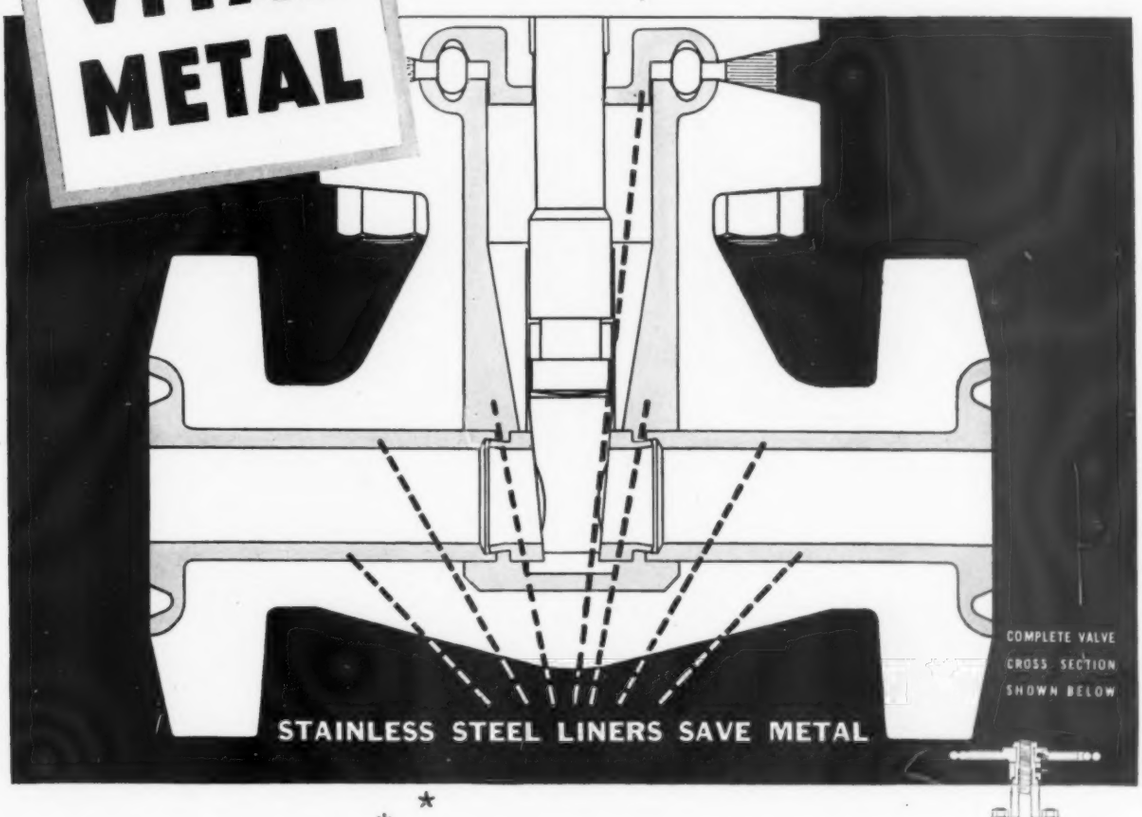
Prepared by
Committee on Transportation:
W. Alton Jones, Chairman

PETROLEUM INDUSTRY WAR COUNCIL
1625 K St., N. W., Washington, D. C.

March 15, 1943

SAVE UP TO 75% OF VITAL METAL

with Vogt STAINLESS STEEL LINED DROP FORGED STEEL VALVES*

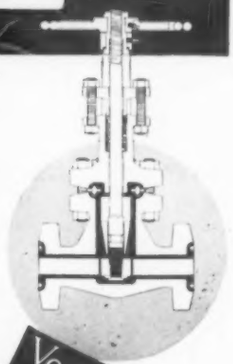


Vogt*

GATE VALVE AND SLIDE VALVE TYPES AVAILABLE

The War Program demands conservation of all strategic metals that are vital to victory. Therefore, by specifying stainless steel lined valves in flow control services involving severely corrosive-erosive or high temperature liquids and gases, as much as 75% of the vital metal can be saved . . . a definite contribution to the war effort!

Vogt *stainless steel lined* drop forged steel gate and slide valves are serving today in many applications throughout industry. Liners of the stainless analyses for specific operating conditions are of 3/16" minimum thickness and usually extend to the contact surfaces of the three body flanges for extreme service conditions.



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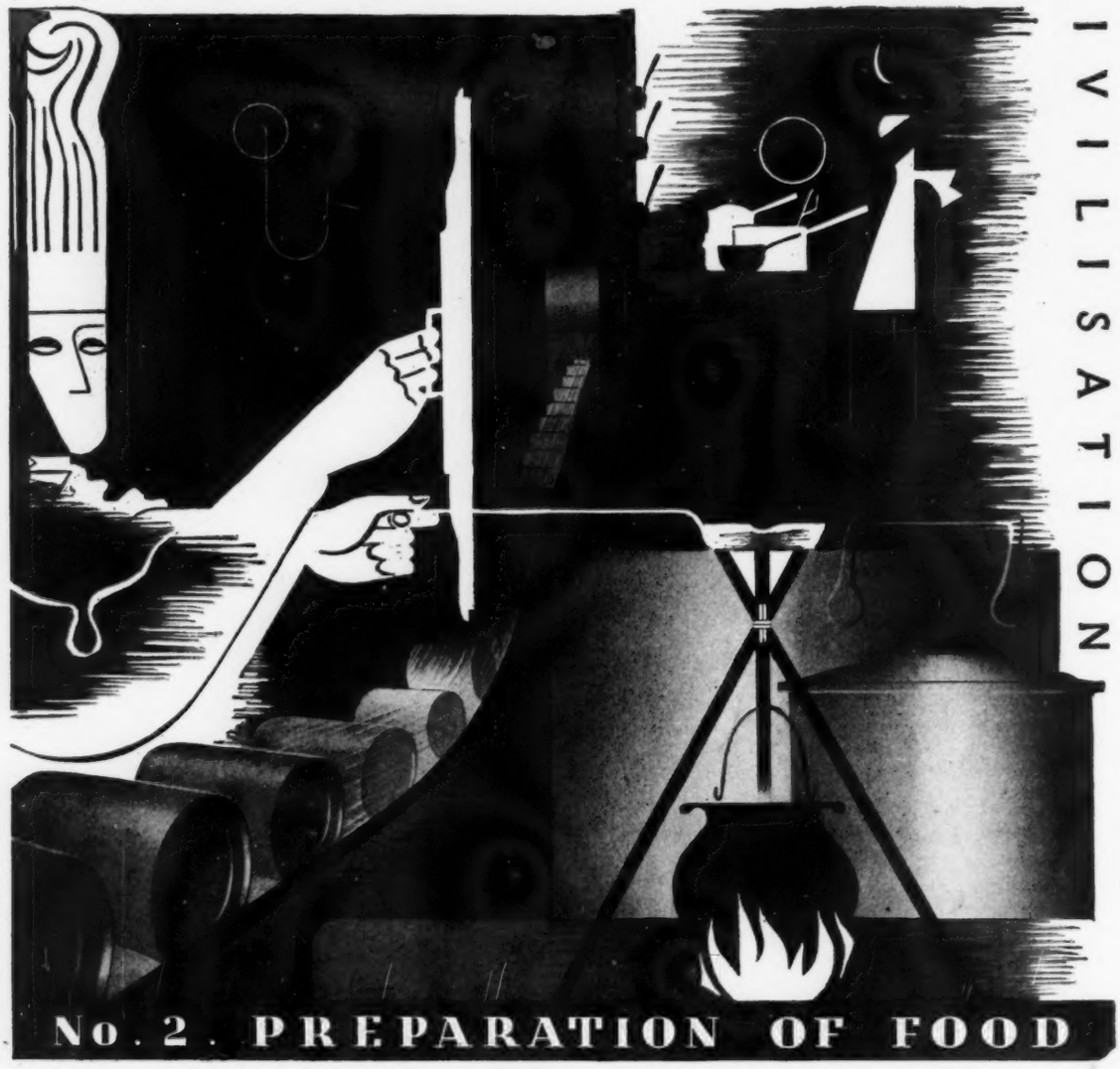
GET IN THE SCRAP

WORLD PETROLEUM (including Petroleum Equipment Exporter) Vol. 14, No. 13, December, 1943. Entered as Second Class Matter April 15, 1943, at the Post Office at New York, N. Y., under the act of March 3, 1879. Published monthly August to June, semi-monthly in July, by Estate of Russell Palmer, Mona Palmer, Executrix, at 2 West 45th Street, New York 19, N. Y. Subscription price $5.00 a year, single copies 50 cents each.

FUNDAMENTALS OF CIVILISATION



No. 2. PREPARATION OF FOOD

Man cooks his food and thus differentiates himself from the animals. By applying heat to the ancient cooking pot, it was discovered that food was not only made palatable but was also preserved.

The original cooking of food as a satisfying appeal to the appetite also unconsciously served the needs of hygiene.

In modern times, the degree of hygiene attained in the preparation and preservation of food has become a measure of civilisation. The housewife has her stainless steel kitchen-ware for ease of cleansing; the chef has his untarnishable equipment; and, in the large scale preparation of food, are to be seen vast cauldrons and fabricated vessels of these new gleaming steels.

In the dairy, the butcher's shop, the brewery and in the great canning industries, stainless steel is an up-to-date symbol of progress.

THE UNITED STEEL COMPANIES LTD

THE UNITED STEEL COMPANIES LIMITED

STEEL, PEECH & TOZER, SHEFFIELD
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THEY GAVE AMERICA A "FLYING START"

The following companies are operating or have under construction

59 HOUDRY AND T.C.C. UNITS

ASHLAND OIL & REFINING COMPANY
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CROWN CENTRAL PETROLEUM CORP.
GENERAL PETROLEUM CORP. OF CALIFORNIA
GULF OIL CORPORATION
MAGNOLIA PETROLEUM COMPANY
THE PURE OIL COMPANY
RICHFIELD OIL CORP.
SINCLAIR REFINING COMPANY
SOCONY-VACUUM OIL COMPANY, INC.
SOUTHPORT PETROLEUM CO.
STANDARD OIL CO. OF CALIFORNIA
STANDARD OIL CO. (OHIO)
SUN OIL COMPANY
TIDE WATER ASSOCIATED OIL COMPANY
UNION OIL CO. OF CALIFORNIA

There has been no greater contribution to the war effort than catalytic cracking

As we near the second anniversary of America's declaration of war, we may well give due credit to the five leading oil companies which were first to adopt the Houdry Catalytic Cracking Process.

Whether by fate or foresight, they were ready. The day the dreadful news of Pearl Harbor broke upon an unsuspecting and unready America, these five companies—Socony-Vacuum, Sun, Magnolia, Tide Water Associated and Standard of California—had 14 Houdry catalytic cracking units in operation and two more nearing completion. Within a few months, most of these facilities had been converted to the manufacture of this war's most critical material, high octane aviation gas.

These pioneers of catalytic cracking soon were joined by other leading petroleum refiners. Sixteen companies are now operating or building Houdry and T. C. C. units. They include many of the industry's best known names and represent more than 50% of total U. S. refining capacity.

During two critical years of a war whose issues have been mainly decided in the air, Houdry licensees have carried almost the entire load of producing catalytically cracked aviation gas for the United Nations. Today, 23 out of the 27 catalytic cracking units in operation are Houdry-licensed units. Thirty-six more Houdry and T. C. C. units are being built.

Houdry Catalytic Processes and the Thermofor Catalytic Cracking Process are available to all American refiners, under license arrangements, subject to approval by the United States Government.

HOUDRY CATALYTIC PROCESSES
... FOR VICTORY IN WAR
... FOR PROGRESS IN PEACE

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UNDER THE TOUGHEST OPERATING CONDITIONS

MULTI-SET PACKING RINGS

—fabric wrapped synthetic rubber core or solid synthetic rubber—provide a five-fold safety seal-off under high pressures. Fluid or gas trapped between the rings distributes pressures equally and assures a positive seal. With these rings designed for severe duty, the Packer can be set and reset many times even in the heaviest mud.

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prevents over-expansion of the Multi-Set Packing Rings and protects the packer mandrel (tube or body) from collapsing strains —an additional precaution against the hazards of severe operating conditions.

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permits the packer to be rotated for setting and resetting independent of the cage assembly, thus eliminating the possibility of twisting the slips in the cone and damaging casing or the slip assembly.

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made of high test steel provide maximum contact area with the casing or tubing and prevent hanging up in whipstock windows or casing collar joints.

As the world's largest manufacturers, distributors and exporters of the multiple ring oil and gas well tubing and casing packers, Lane-Wells Company builds a complete line and maintains stock for 24-hour service in its factory and 30 field branches

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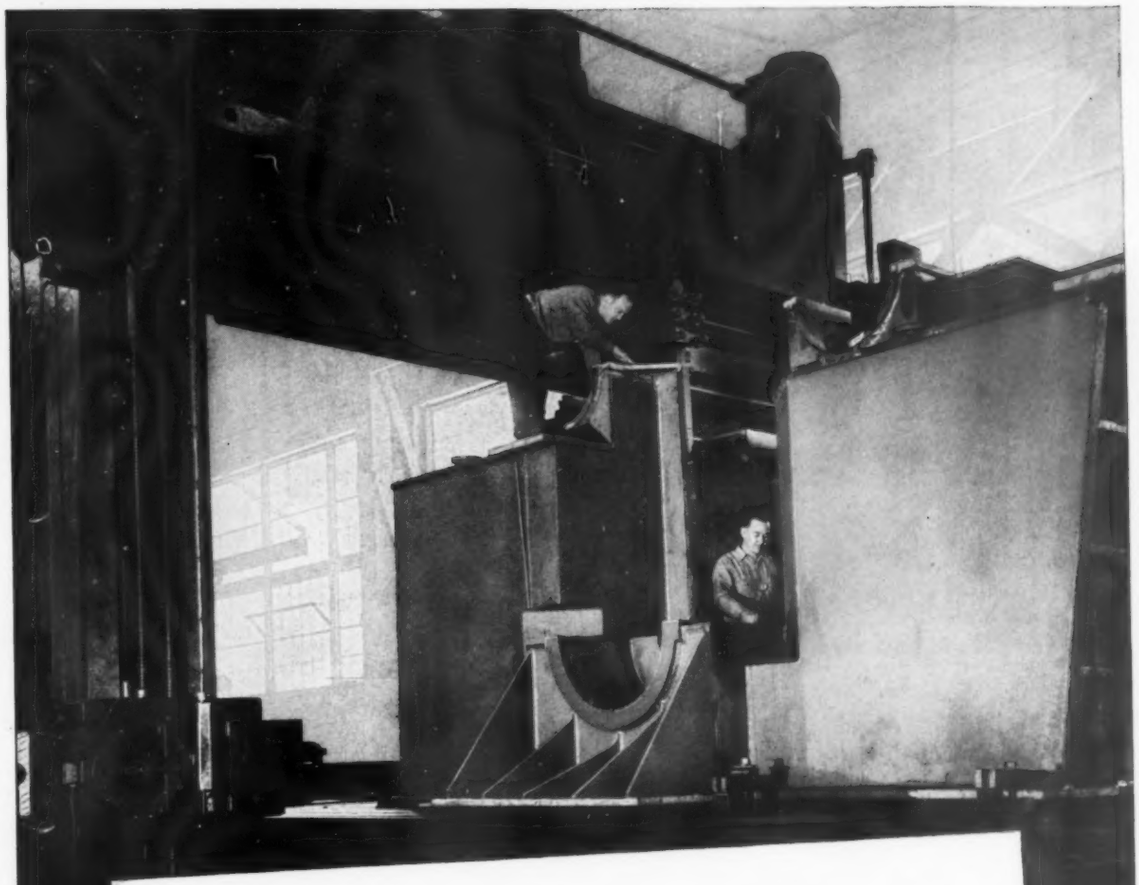
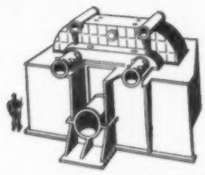


"Barber Chair" FOR A 21-TON GEAR CASE

Here's probably the biggest "barber chair" you've ever seen! And its current customer is a 21-ton gear reduction case for the new 8,500 h.p. Hendy steam turbine units being "shaved" in meticulous thousandths of an inch.

This "chair" is known as a planer and its load capacity of 75 tons on a 510 sq. ft. bed shows the tremendous size of the jobs that Hendy is equipped to handle.

However, this planer is only one unit in the vast array of major equipment that is helping Hendy and its divisions set unprecedented records for turning out massive power equipment with straight-line production methods.



For the Maritime Commission and the Navy Department Hendy production includes steam turbines and reduction gear units up to 8,500 h.p., Liberty and Frigate steam engines, turbo-lighting sets, naval ordnance, hydraulic pumps, motors and generators.

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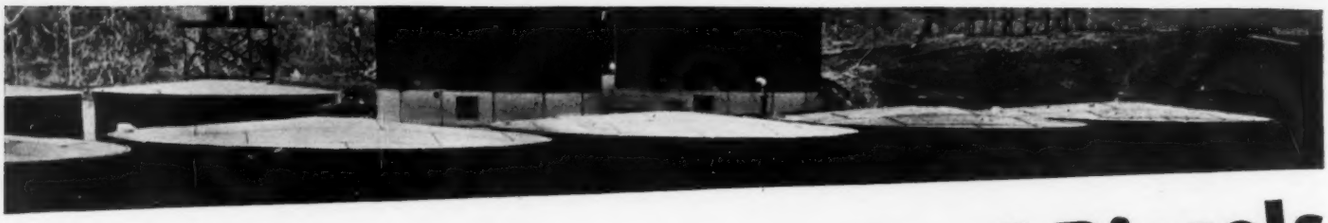
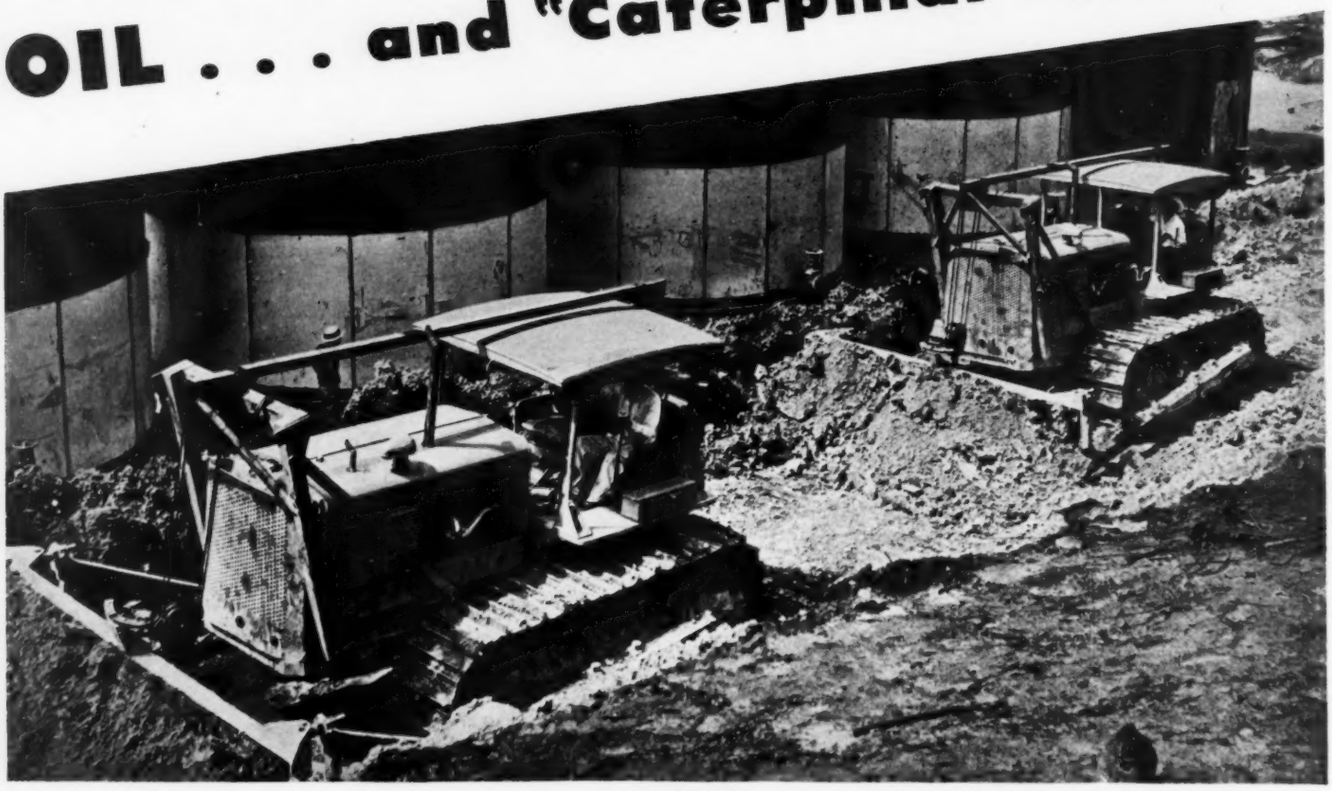


OIL . . . and "Caterpillar" Diesels



● **COLOMBIA.** *Two "Caterpillar" Diesel D8 Tractors with LeTourneau Angledozers build up a protective base around storage tanks on a large oil property*

WAR is a ravenous consumer of the world's petroleum supply. New fields must be opened; old ones spurred to produce more. In both, the big work-volume of "Caterpillar" Diesel equipment is needed to speed wells and refineries into maximum production, build pipelines, roads, tanks for storage and wharves for ship-loading.

Tough, powerful "Caterpillar" Diesel Tractors are at work on all such projects — breaking trails, clearing well sites, building roads, yards and docks, digging slush pits and drainage ditches, pumping oil and water, powering boats and lighters. And "Caterpillar" Diesel Electric Sets are furnishing light for all types of oil operations.

In other fields as well—mining, construction, agriculture, manufacturing — "Caterpillar" Diesel power is serving the free nations valiantly. At present, the entire output of the huge "Caterpillar" factories is going into war-essential operations. Meantime, a far-reaching service-dealer organization is able and eager to help keep your present "Caterpillar" Diesel equipment at work. When peace comes, a flow of new "Caterpillar" Diesel products will speed the drive toward the greater prosperity which lies ahead.

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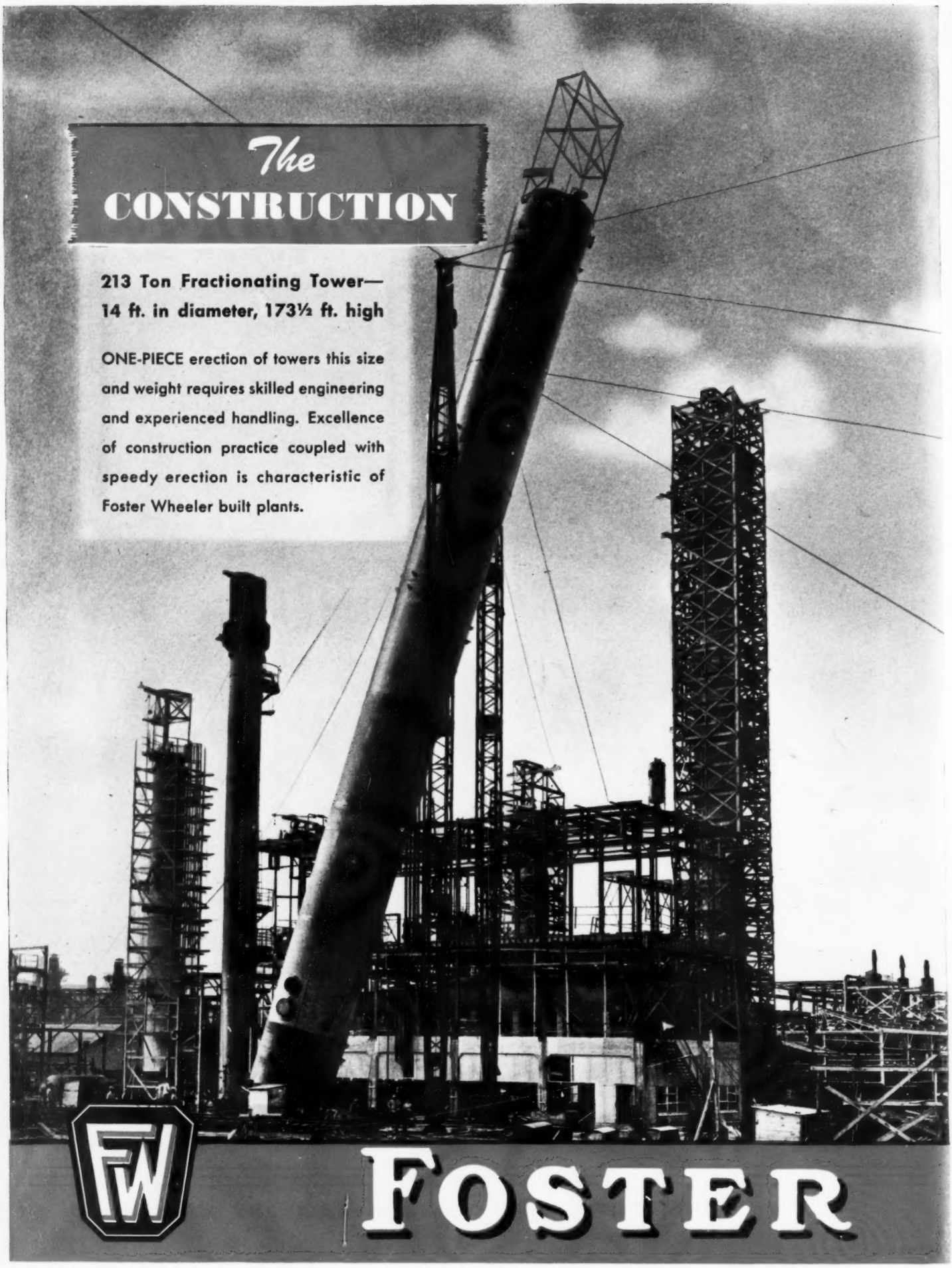
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213 Ton Fractionating Tower—
14 ft. in diameter, 173½ ft. high
ONE-PIECE erection of towers this size and weight requires skilled engineering and experienced handling. Excellence of construction practice coupled with speedy erection is characteristic of Foster Wheeler built plants.
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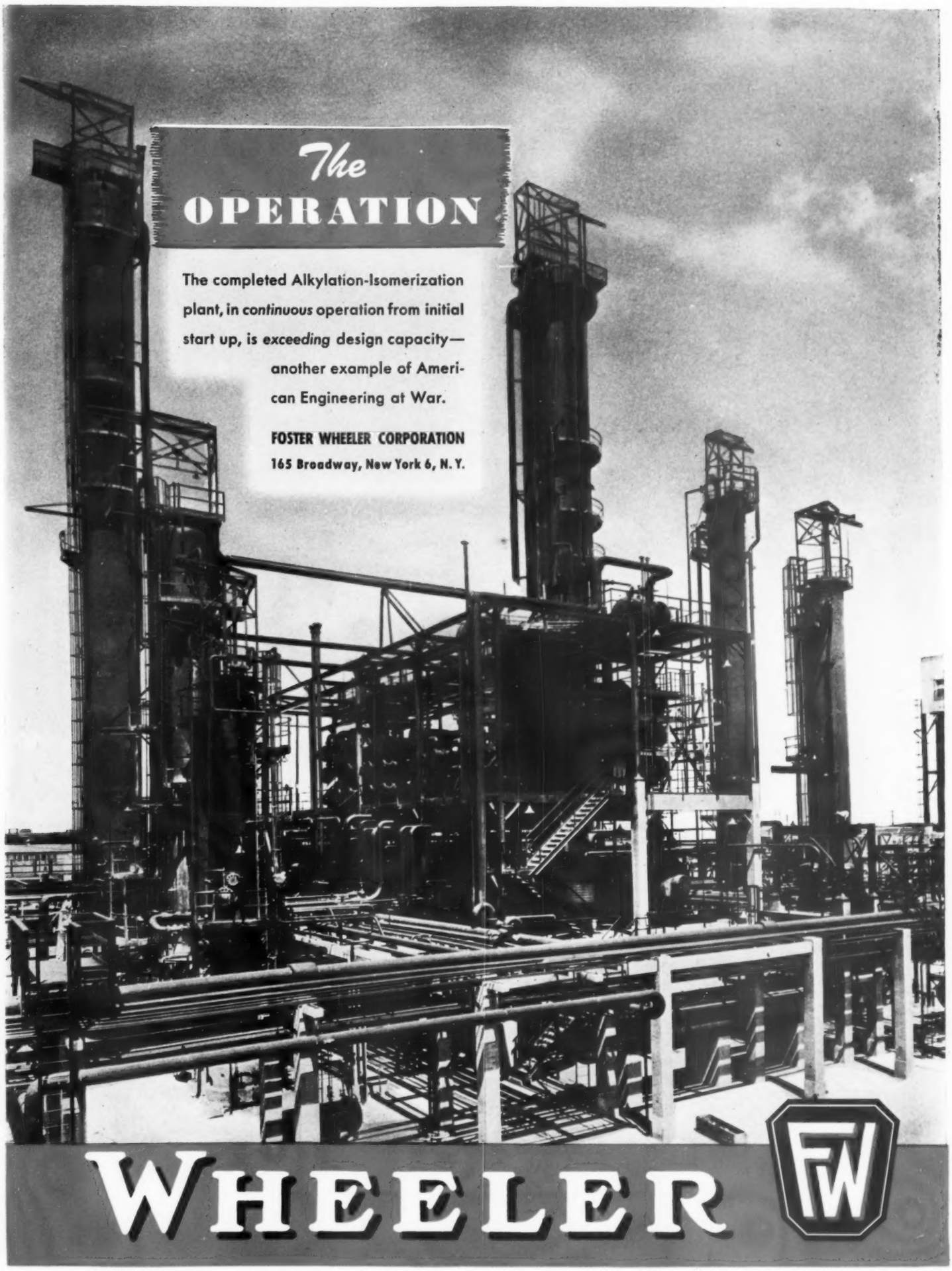
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OPERATION
The completed Alkylation-Isomerization plant, in *continuous* operation from initial start up, is *exceeding* design capacity—another example of American Engineering at War.
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McKEE REFINERY ENGINEERING

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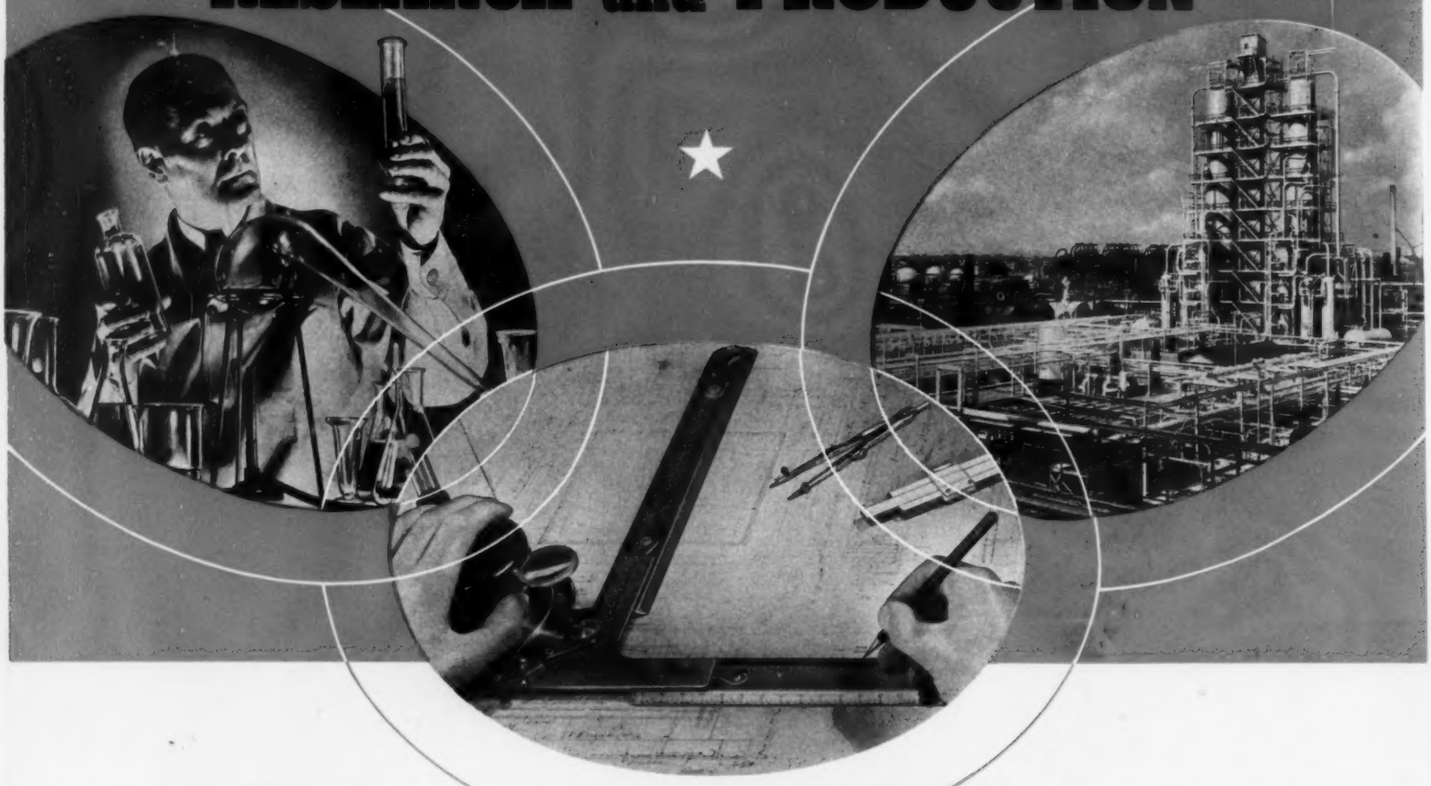
RESEARCH and PRODUCTION



LABORATORY progress can be converted into practical production only by sound refinery engineering. The McKee organization is well qualified by personnel and experience to perform this function.

McKee process specialists keep up to date on all new developments in refining techniques. McKee refinery engineers are thoroughly familiar with the requirements of modern operation.

The McKee staff of technical experts and skilled construction personnel, with many years of world-wide experience, provide a *complete* service capable of handling all phases of your refinery project in *one* organization.

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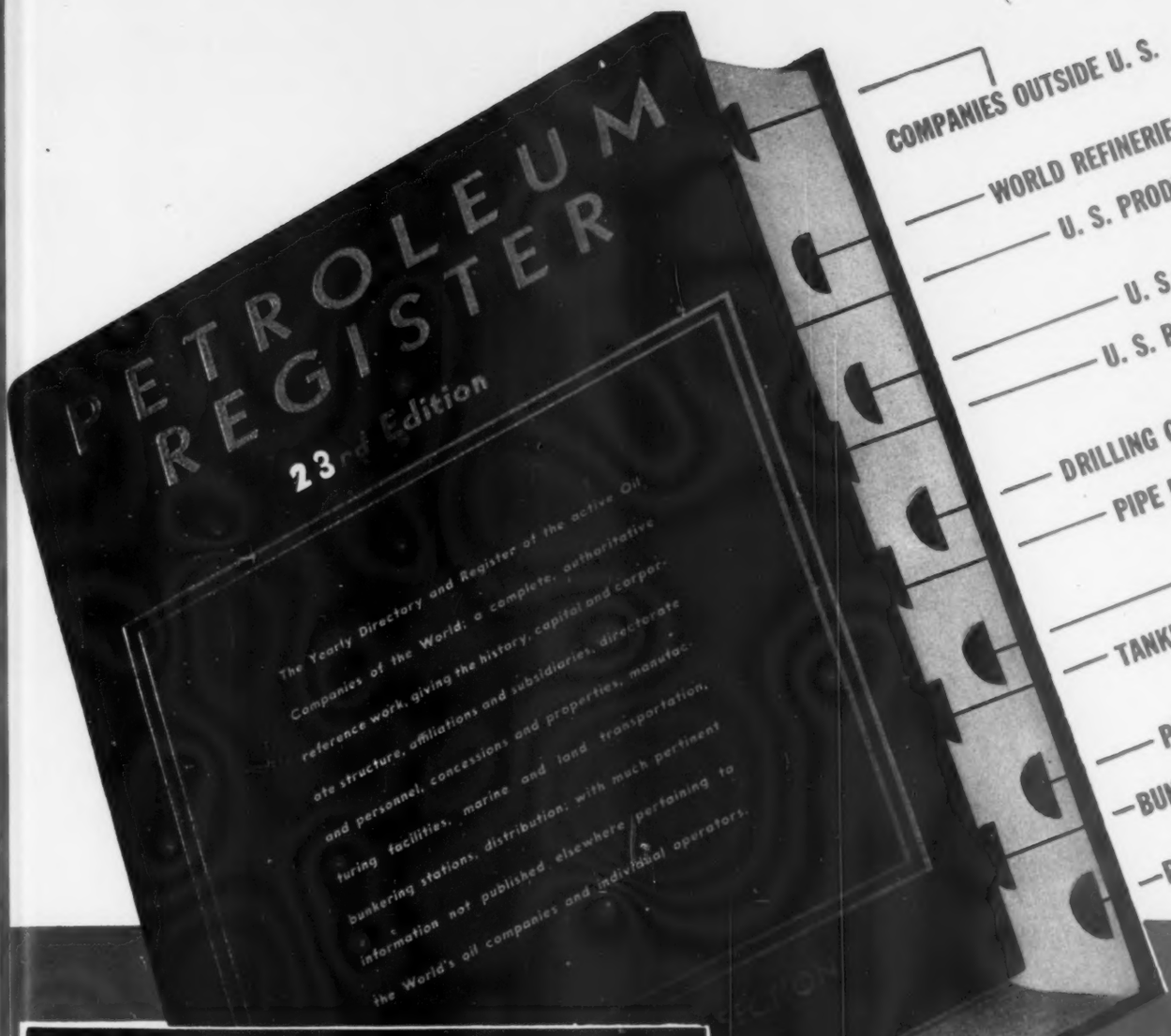
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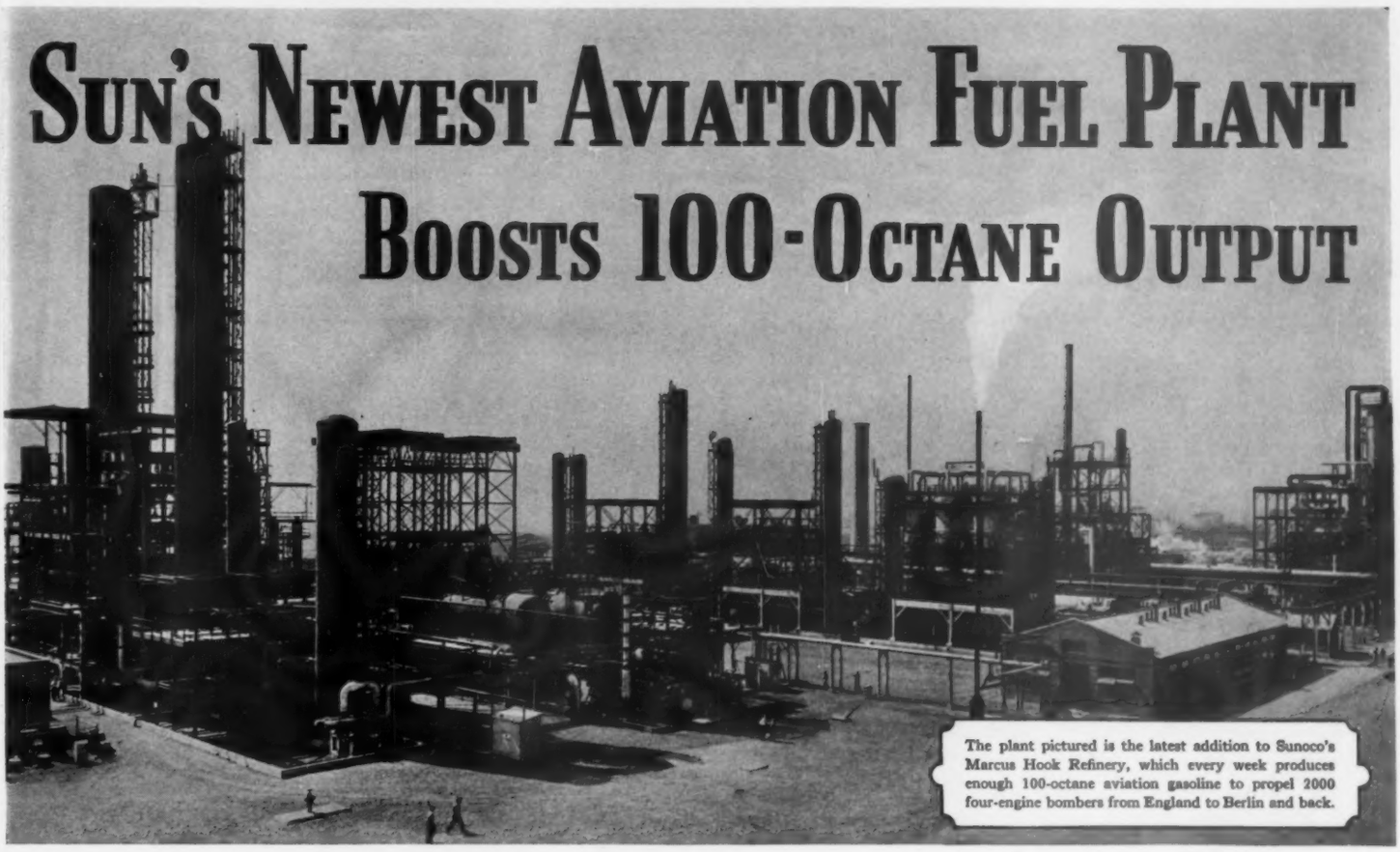

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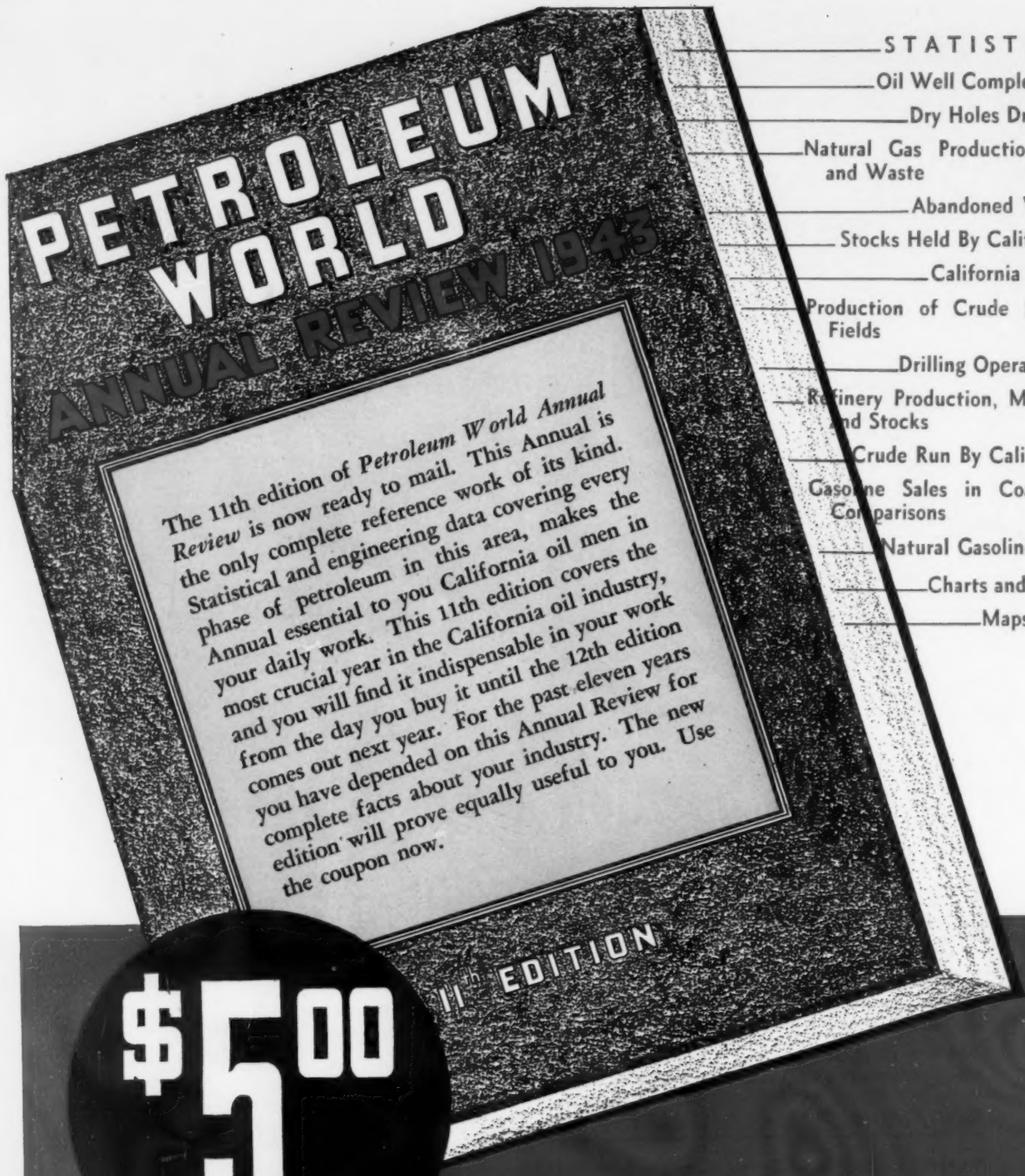
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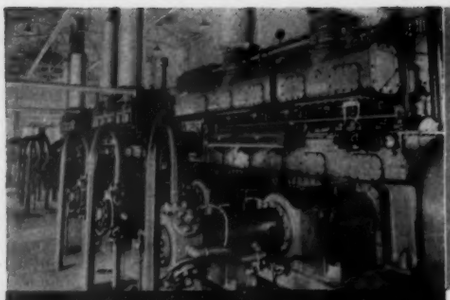

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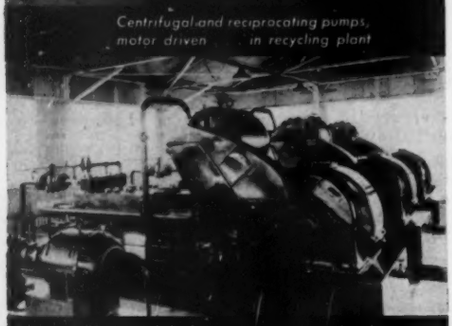
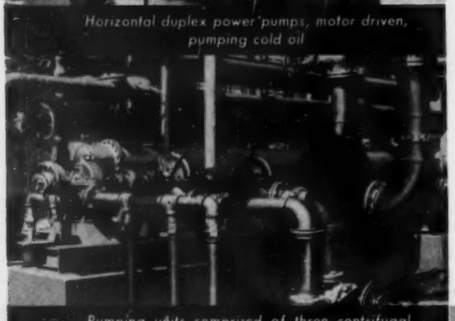


Horizontal duplex power pumps, motor driven, pumping cold oil



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A group of HiVol steam pumps handling highly volatile liquids

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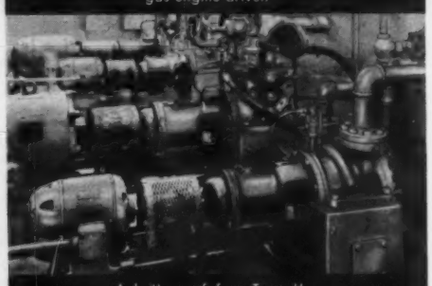
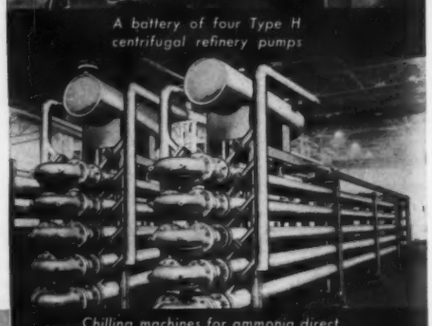


A battery of four Type H centrifugal refinery pumps



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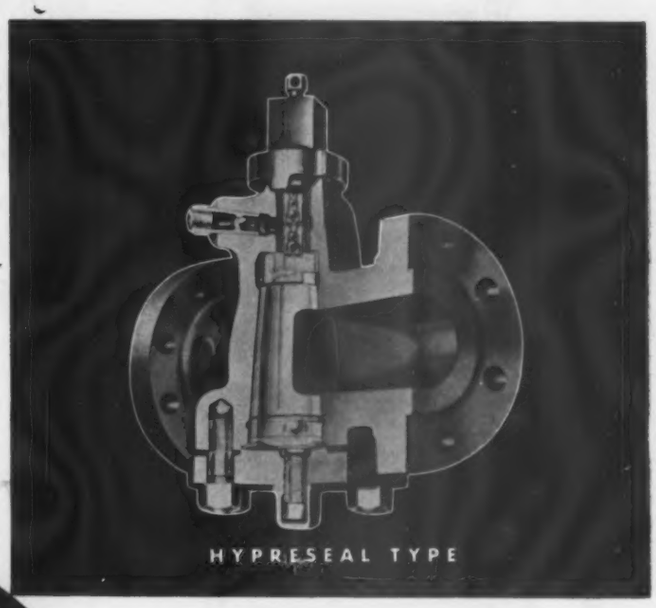

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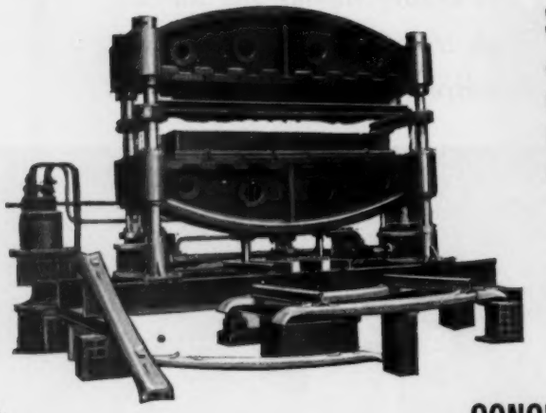

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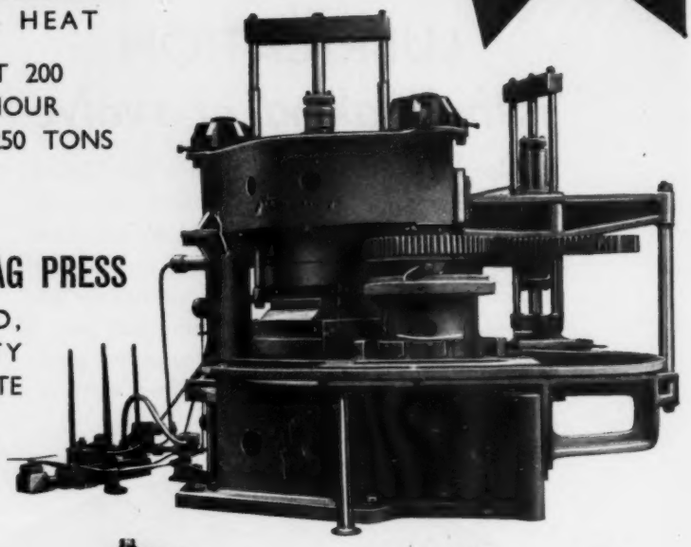

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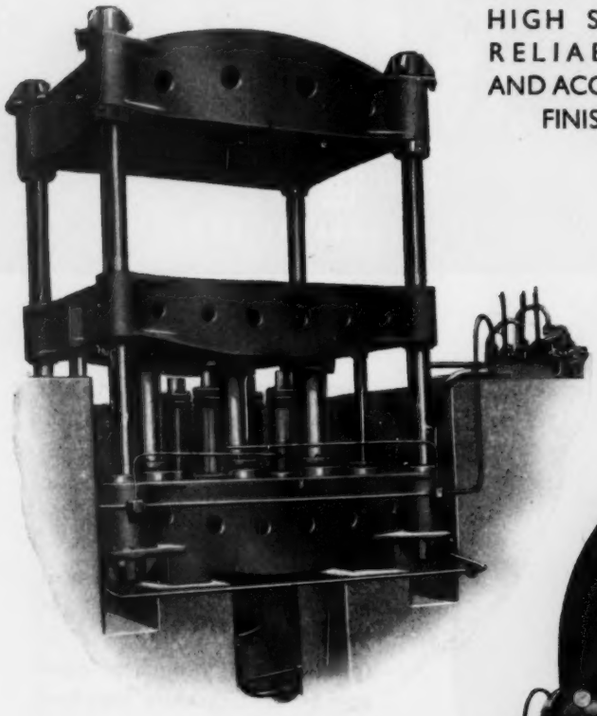

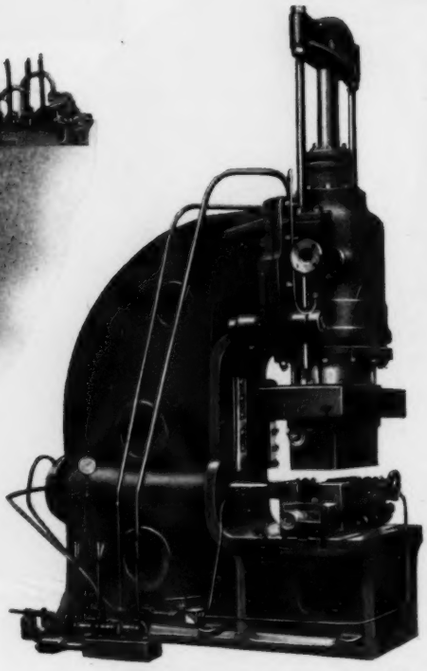

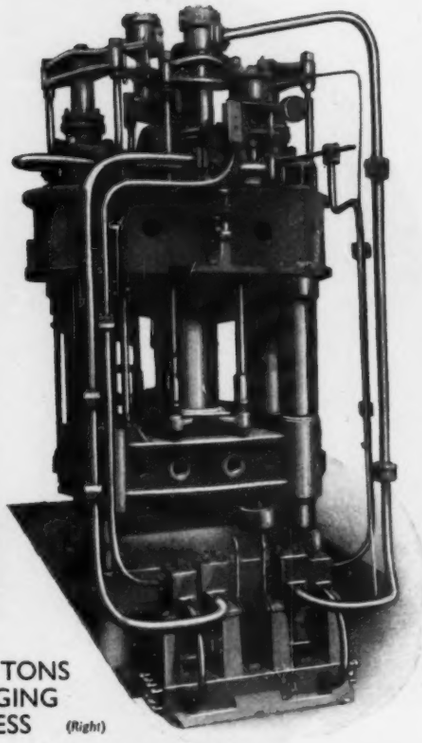

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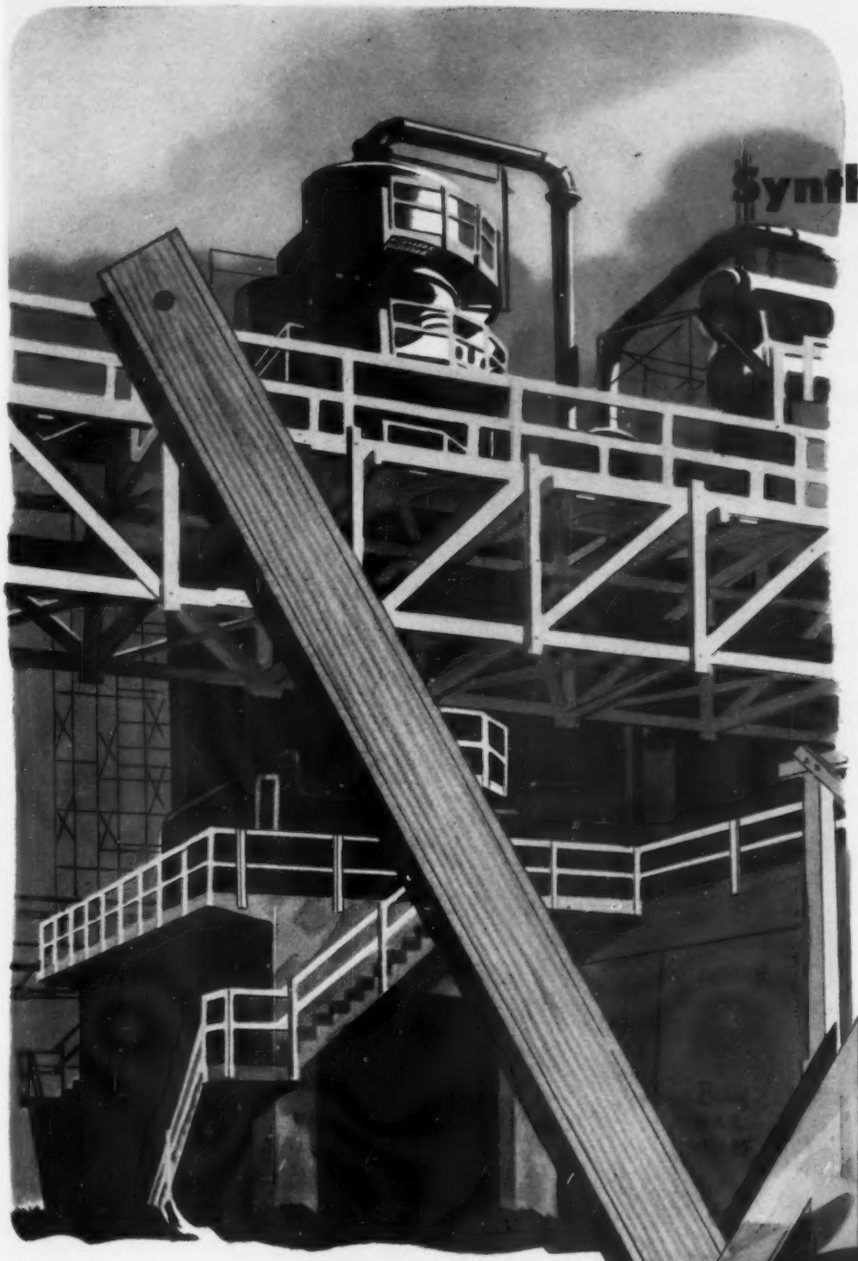

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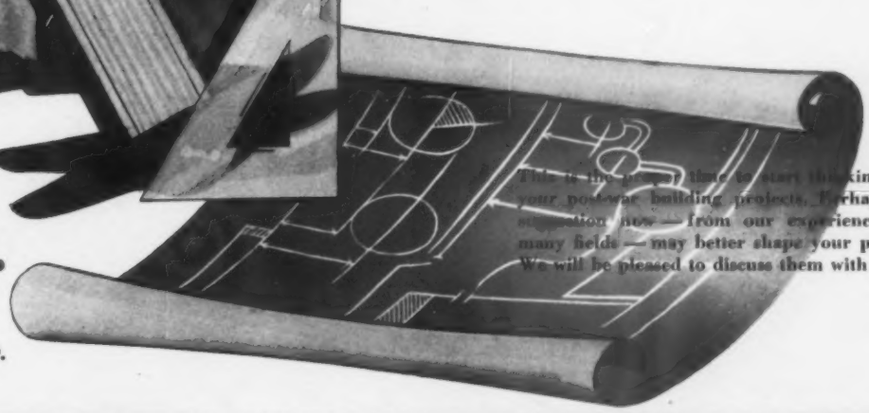

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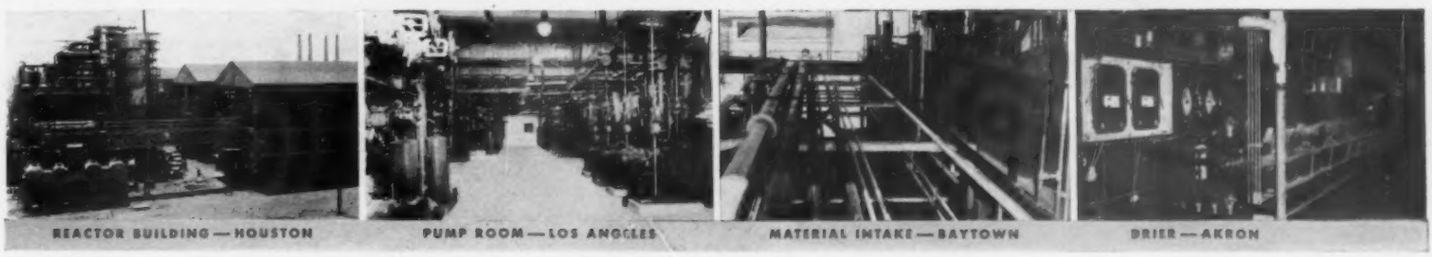

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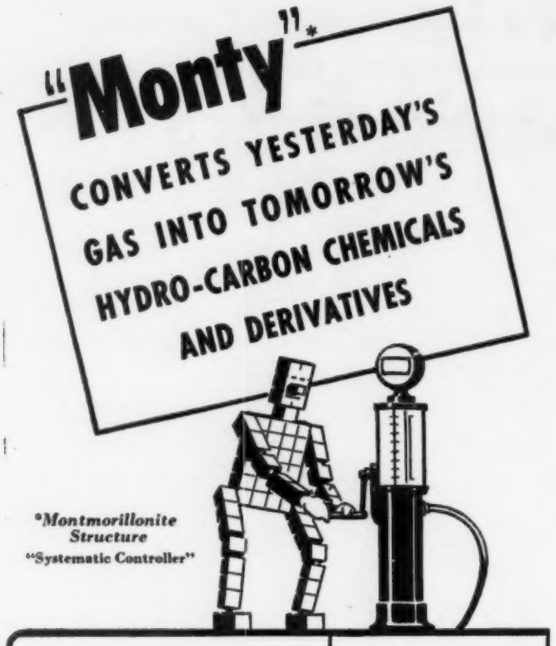

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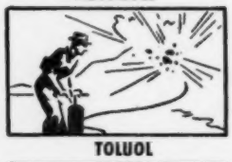
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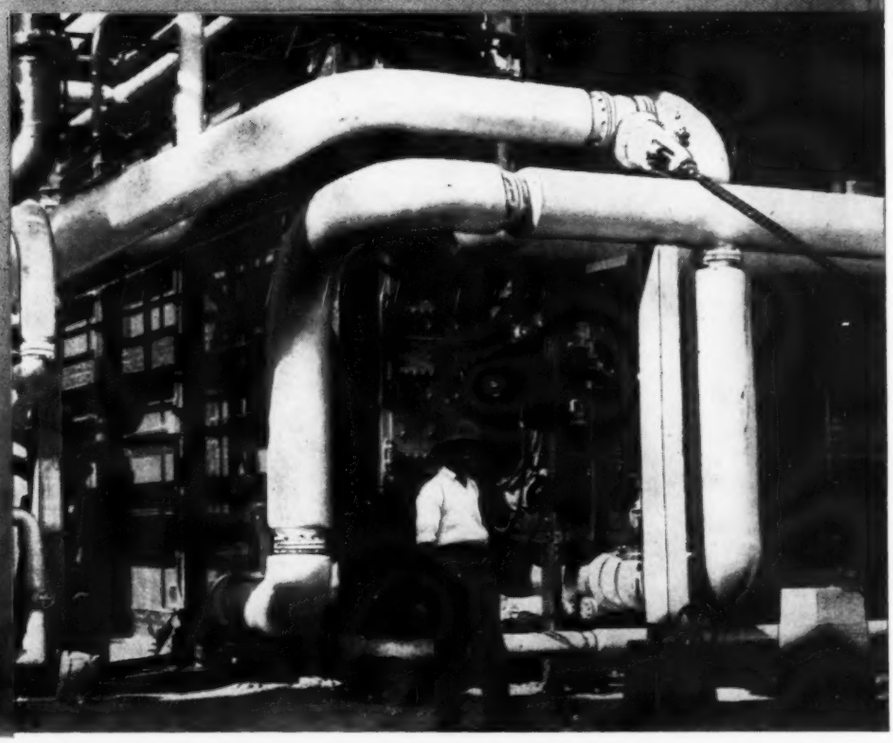

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